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LAYING A SUBMERGED WATER PIPE AT NORTH TONAWANDA, N. Y.

The laying of submerged pipe lines across deep bodies of water are always subjects of interest to engineers. The city of North Tonawanda, N. Y., has recently completed the laying of a 24-in. cast-iron submerged water pipe line across the Tonawanda harbor branch of the Niagara River.

The cities of Tonawanda and North Tonawanda, suburbs of Buffalo, N. Y., adjoin one another, being divided by Tonawanda Creek, which also forms part of the Erie Canal at this point. The mouth of this creek is about 12 miles north of the mouth of Buffalo River, in the city of the same name. Both Tonawandas procure their water supply from the east branch of the Niagara River, off Grand Island. The location of the intakes and pumping stations is shown on the map, Fig. 1.

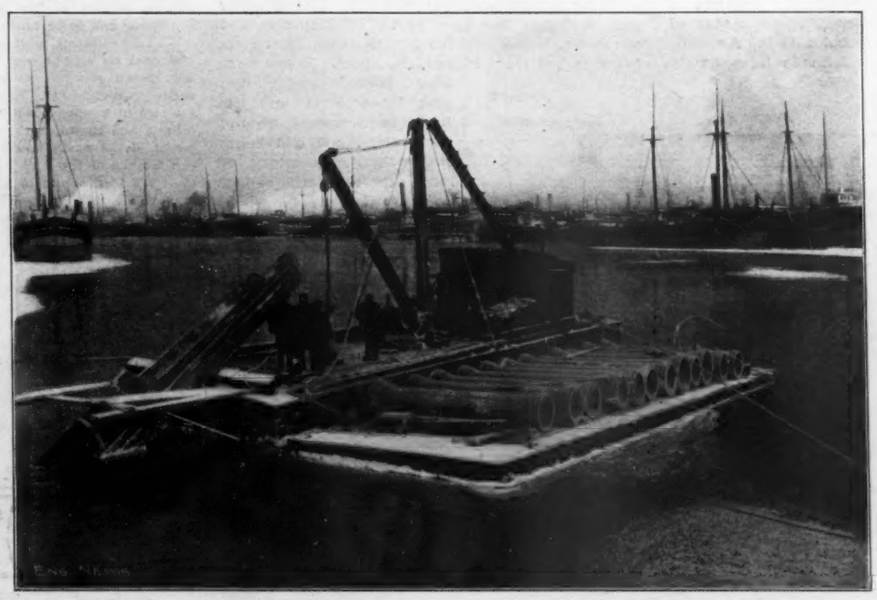
Up to a short time ago the water supply for North Tonawanda was furnished by two submerged pipe lines across the Tonawanda harbor; one, a 12-in. line, crossing the river at Thompson St., and the other, a 24-in. line, crossing at Wheatfield St. Both lines are made of flexible-joint cast-iron pipe. The line at Thompson St. shows signs of leakage, due probably to a broken pipe, and is not used at the present time.

Lately a new supply pipe line was decided upon, extending from the pumping station on the west side of Tonawanda Island, at the foot of Bridge St., along this street to Tonawanda harbor, crossing this diagonally to the foot of Thompson St., and thence along the latter, making connection with the present system of distribution. A 24-in. cast-iron pipe line was decided upon, consisting of the ordinary pipe for the land parts. For the river crossing it was decided to use the John F. Ward flexible-joint pipe, made at the Burlington, N. J., plant of the United States Cast Iron Pipe & Foundry Co.

Several plans for doing the work were considered, but it was finally decided to have the city buy all the pipe and have the river crossing portion laid by contract, the work being let to Messrs. William E. Hingston & Co., of Buffalo, N. Y.

Fig. 2 shows the crossing of both the old and new pipe lines. The United States government is at present engaged in dredging Tonawanda harbor to a depth of 18 ft. below mean river level, and in anticipation of still deeper dredging it was required that the new pipe line should be laid with at least 23 ft. of water over it. This required the dredging of a trench in which to lay the pipe about 8 or 9 ft. deep, after making proper allowance for the pipe and the possible silting up of the excavated trench. This work presented no unusual difficulties. The material excavated was clay and clay mixed with gravel and small cobbles, a kind of a hardpan. The laying of the pipe was begun soon after the trench was completed, and the plant employed in this work was a derrick scow, a material scow and a timber skid.

The hull of the derrick scow is 51 ft. long, 17½ ft. wide and 5 ft. high. A guy derrick is built on this with the mast supported by two stiff legs and two guy rods. The lower end of the boom is secured to the deck of the scow by a pintle, around which it swings. The derrick is worked by hand power. Behind the derrick is located a small storehouse, 6 × 12 ft. in dimensions. This is used for storing supplies of all kinds, and also contains a small stove for heating water and the clay ropes for the pipe jointer. At the forward end of the scow is a capstan, also worked by hand with the usual capstan bars.



PLANT IN OPERATION IN MID-STREAM; LAYING FLEXIBLE-JOINT PIPE AT TONAWANDA, N. Y.

The material scow used for transporting the water pipe is about 48 ft. long, 16 ft. wide and 3 ft. deep. The sliding ways or skid is made up of two timber spars, each about 70 ft. long, 15 ins. diameter at the larger and 8 ins. diameter at the smaller ends. The spars were spaced about 3 ft. apart c. to c. At the upper end they were fastened together by short cross pieces bolted and spiked, and for the remaining length (under water) the spars were kept separated by planks about 18 ins. wide, kept in place by rope lashings. This arrangement was adopted so as to allow the easy separation of the two spars forming the skid, on the completion of the pipe laying, by cutting the lashings.

Fastened to each spar were, first, a course of 2-in. pine plank, on top of which was secured a 3-in. oak plank. These planks were placed at an angle of about 45°, thus forming a trough, in which the pipe lay. To hold the scows in position while working, lines were run to convenient fastenings, in this case mainly to the adjacent railroad swing bridge, its piers, fenders, etc., and also to mooring posts on the docks.

The method followed in laying the pipe was as follows: The work was begun on the west or island shore, the initial pipe having been laid in a trench dug well down to the water level. The two long spars forming the skid, which had been placed on the material scow, were then run up under the shore pipe, after which four lengths of pipe were placed together, the material scow being gradually pulled out into the stream as each pipe was leaded up. The skid was then transferred to the derrick scow.

The next operation was to advance the skid, so as to make room for another pipe. This was accomplished by a double block attached securely to the skids, about water level, and a single block was next attached to the bell end of the last pipe by means of a chain. The free end of the pulling line was then passed around the capstan and the line drawn taut. As the derrick scow moved with the skids, there was virtually no movement so far as the relative position of derrick, scow and skids were concerned. It appeared as if the pipe slid down the ways, while in reality the ways slid up the pipe. This operation was repeated with each pipe laid until the stream was gradually crossed. The daily progress varied; some days but two pipe were laid, on other days, six to eight.

On the completion of the work a diver was sent down and the spar lashings were cut; this allowed the spars to be separated and ultimately floated to the surface.

It might be added here that this method of

fastening was the outcome of an experience had with a pipe line laid some years ago, where the spars forming the ways had been bolted and spiked together, entailing considerable work and expense in their separation.

Both ends of the pipe line now being above water level, the next operation was to test the pipe for tightness. Each end of the pipe was first closed with a large tight-fitting wooden plug, securely held in place by the arrangement here

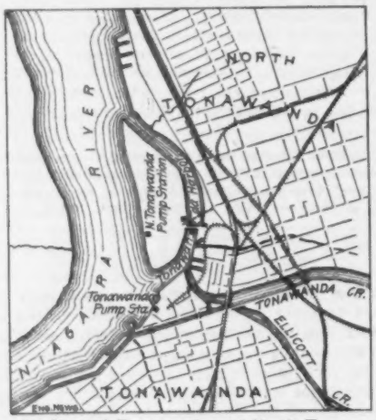


Fig. 1. Map of Tonawanda and North Tonawanda; Showing Pipe Crossings.

shown in Fig. 8. This consisted of a collar, A-B, composed of two semicircular bands of flat iron with ears and holes. Two bolts, C-D, with eyes, were placed between the ears and the whole bolted together. The screw ends of the bolts passed through a heavy piece of timber, E, and two blocks of wood, F, were placed between the timber, E, and plug, G, to distribute the pressure

The timber, E, was tightened up by means of the nuts in the ends of the bolts, C-D. An ordinary service connection was made immediately

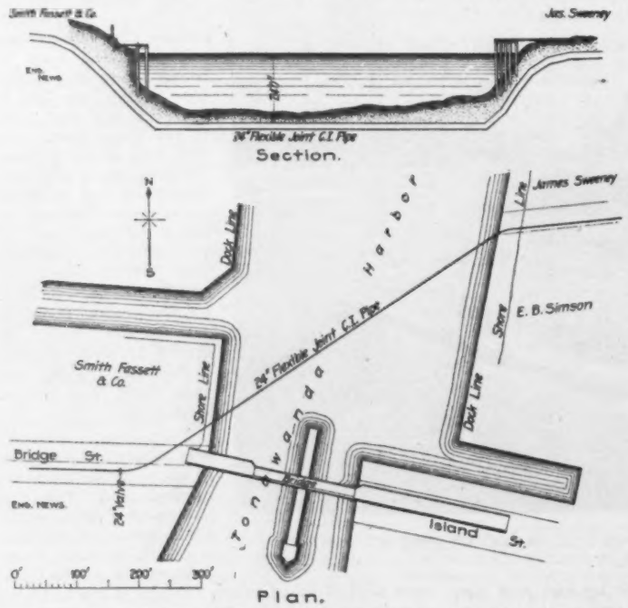


FIG. 2. PLAN AND SECTION OF CROSSING OF SUBMERGED PIPE LINE.

back of the bell, to which an ordinary ¾-in. pipe was attached. A pressure gage was placed in this pipe and connection was then made with an adjacent fire hydrant. In this small pipe line a water meter was inserted to measure the leakage, if any, and also a small hand force pump to run up the pressure. After all connections had been made, the water was turned on, and the pressure at the pumping station run up to 58 lbs., the test showing no appreciable leakage. Owing to the circuitous route of the force main, the distance between the pumping station and the fire hydrant used was about one mile.

The city engineer, Mr. A. P. Smith, however, was not satisfied with the test, and a few days later made another, using a fire engine to secure a greater pressure. In place of the smaller pipe, a large hole was bored in the plug and a 3½-in. pipe was attached. After all was in readiness, the fire engine was started, but no pressure whatever was indicated, showing something radically wrong. An investigation of the pipe line by a diver followed, and it was found that there was a small hole in the top of the fifth pipe from the island end. This hole was apparently oblong in shape, about 4 ins. long and 2 ins. wide. As the pipe line in this condition was, of course, unserviceable, the next step was to remedy the defect, and the only alternative was to raise the island end of the pipe and ascertain the extent of the damage and the probable cause.

To accomplish this, the floating plant was again brought into requisition. It was moored near the island shore, the derrick scow on the down-stream side, with the lighter above. Blocking was placed at intervals on the lighter, along the adjoining side, and on this 12 × 12-in. timbers were laid, their tops even with the deck of the derrick scow. The space between the floating plant and the dock was spanned by two 12 × 12-in. stringers, about 24 ft. long each, one end resting on the outer edge of the dock, the other on the plant. Two other stringers were placed, one end resting on the inner end of the dock and the other on a cross timber supported by the shore. The inside spacing of the stringers was about 3 ft. The structure, of course, was in the alinement of the pipe line and over the pipe.

A number of rollers had also been provided. These were lengths of 6-in. wrought-iron pipe, 5 to 6 ft. long; near one end of each six 1-in. holes had been drilled in such an order that every two were opposite each other. There were ten of these rollers, all resting in grooved blocks; five pairs of these blocks were supported by the stringers and the other five pair partly by stringers and partly by the deck of the derrick scow, the rollers being placed from 10 to 12 ft. apart. Ropes were then passed under the pipe by a diver and the loose ends passed around the rollers, one end being made fast. By means of large pipe tongs the rollers were slowly rotated, winding up the rope. In other words, the arrangement was nothing more than a windlass. After a sufficient amount of rope had been wound up it was made fast, and to keep the roller from turning

Fig. 3. Section, Showing Spar-cradle for Launching the Flexible Pipe.

an iron pin was inserted through one pair of the holes previously mentioned, one end of the pin impinging on the stringer, block or deck, as the case might be.

The work of raising the pipe was begun on Monday and by Saturday the broken pipe was out of the water, some delay having been caused by the splitting of one of the roller supports. The hole in the pipe was plainly visible; it was situated at the spigot end of the fifth pipe, a little off the center of the pipe, and about one foot from the end. The city's representatives claimed that the hole was caused by the contractor, during the operation of replacing the pile dock, by inadvertently placing a pile on the pipe, the force of the blow from the fall of the 1,600-lb. weight of the pile driver being sufficient to cause the damage. The defective pipe was taken out, the lead joints being burned out with a Buckeye light. The four land-end lengths of pipe were bodily drawn forward and pipe No. 4 was entered into pipe No. 6 and re-leaded. Another pipe was inserted into No. 1, thus restoring the original arrangement. The raised pipe line was then lowered gradually into place by slacking up the lines holding it.

A test of the repaired line was made on March 5, 1904, in presence of the Board of Water Commissioners and the City Engineer. A fire engine was used for the purpose, putting on a pressure of 110 lbs. However, a pressure of 100 lbs. was first applied several times before the higher one was used. Afterwards a 1-in. meter was attached next to the pipe and water supplied to it through a 2½-in. fire hose at 40 lbs. pressure from the hydrant; in this way 21 lbs. pressure was attained on the pipe, the meter registering 8 cu. ft., or 60 gallons per minute.

A subsequent test showed a leakage of 4 gallons per minute; most of this was from the connections. It is now believed that the pipe is perfectly tight.

We are indebted to Mr. A. P. Smith, City Engineer of North Tonawanda, N. Y., and to Mr. E. Clarence Hingston, the contractor's superintendent, for much of the information from which this article was prepared.

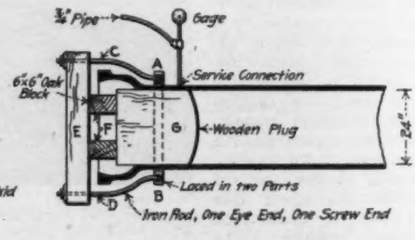


Fig. 8. Sketch of Plug Closing End of Pipe for Pressure Test.

PRODUCER GAS AND GAS ENGINE PLANT OF THE MOCTEZUMA COPPER COMPANY AT NACOZARI, SONORA, MEXICO.*

By John Langton,† M. Am. Inst. M. E.

In determining what kind of power should be adopted for the works of the Moctezuma Copper Co., at Nacozari, Sonora, Mexico, certain considerations imposed by local conditions had to be taken into account.

WATER.—During most of the year, the water supply is abundant for all purposes, but dwindles rapidly when the dry season sets in, reaching a minimum flow which is entirely underground. It was evident, that with the greatest care in keeping down the unavoidable loss of water in milling and smelting, these operations and hence the capacity of the works would be ultimately limited for some two months of the year by the water supply available at this period of minimum flow.

TRANSPORTATION.—The nearest railway terminus was in Arizona, at the international boundary line; and the price of supplies at that point would be enhanced at Nacozari by the additional cost of a 90-mile wagon-haul. During the rainy season, transport to Nacozari was much impeded, and at times made impossible, by the condition of the roads. Hence, to insure continuous operation at the works, it would be necessary to provide for hauling the year's supplies, including fuel for power and coke for smelting, in less than eleven months. In other words, the average freight delivered daily at the works should be at least 10% more than the average daily consumption.

For moderate quantities of freight, pack-carriage by burros is astonishingly cheap. But it has a capacity-limit which is generally very soon reached. A 200-lb. load, and 10 miles a day, 5 with and 5 without load, is the full capacity of a burro. This means one burro per ton-mile of the round trip; and, at this rate, the number of animals to be handled, especially at the unloading point, and required to feed themselves off the country, soon becomes prohibitive.

*Greatly condensed from a paper read before the American Institute of Mining Engineers.

†99 John St., New York City.

There is also a capacity limit to wagon transport, set by the number of teams available without undue interference both on the road, and at loading and unloading points.

FUEL.—The country surrounding Nacozari, being sparsely wooded, mainly with scrub white oak, offered a source of fuel supply of considerable extent, though of poor quality. But the character of the country is so mountainous and broken, that even where a few main wagon roads were feasible without costly road-making, the cut wood could be collected only by burro pack-trains, and so brought to the wagons; while from a great portion of the wooded territory only pack-trails to Narcozari would be possible.

For equal heat values, wood at Nacozari cost at that time much less than coal; but it was decided that a sufficient quantity of wood-fuel for steam power was not

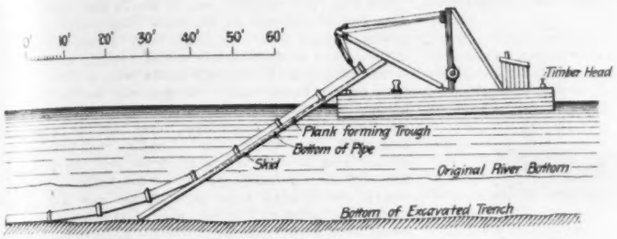


FIG. 4. SKETCH ILLUSTRATING METHOD OF LAYING FLEXIBLE PIPE FROM SCOW.

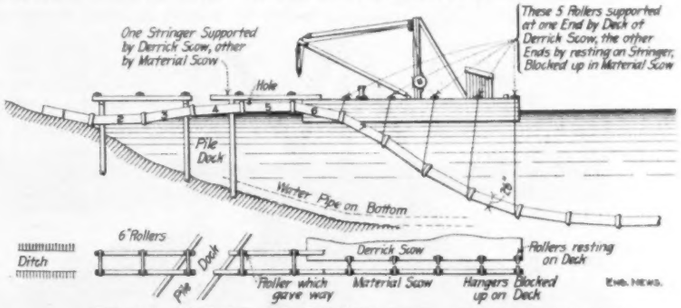

One Stringer Supported by Derrick Scow, other by Material Scow
These 5 Rollers supported at one End by Deck of Derrick Scow, the other Ends by resting on Stringer, Blocked up in Material Scow
Hole
Pile Dock
Water Pipe on Bottom
6' Rollers
Ditch
Pile
Dock
Derrick Scow
Rollers resting on Deck
Roller which gave way
Material Scow
Hangers Blocked up on Deck
Eng. News.

FIG. 9. METHOD OF RAISING PIPE AFTER LAYING TO BRING TO THE SURFACE A DEFECTIVE LENGTH.

available, and that a large proportion of coal would still be needed for boiler fuel.

After 18 months' operation, the cost and difficulties of transport were materially reduced by the construction of the Nacozari Railroad to Cos, 22 miles from Nacozari. Its extension to Nacozari, which is now under contemplation, will further reduce the freights on coal. Meanwhile, the cost of gathering wood has increased with the exhaustion of supply in the immediate vicinity; so that, when the railroad is completed to Nacozari, the two fuels will cost approximately the same for equal heat values.

The total power contemplated to begin with was from 500 to 600 HP., of which the concentrator, the converter blowing engine and the furnace blower would be the principal consumers. Compound condensing steam engines of moderate power would be the highest grade of steam apparatus appropriate to the size and location of the plant. Including shrinkage, 3 lbs. coal per B. HP.-hour would be a very good result from such a plant. In comparison with this result, 1.5 lbs. coal per B. HP.-hour was obtainable with gas engines using producer gas. Moreover, besides the greatly reduced fuel-cost, gas power offered very important additional advantages in facilitating the continuous operation of the works at their full capacity: by cutting down the water consumption in the dry season; by reducing largely the stock of fuel needed to tide over periods of interrupted transport; and by reducing the average quantity of daily freight. The effect in alleviating transport difficulties would be increasingly beneficial with that extension of capacity which always follows successful operation.

The fuel economy promised by gas engines had led to their use in supplying all the power needed for a small electrolytic refining-plant, operated by the Copper Queen Consolidated Mining Co., with the view of giving them a practical trial, which would test their mechanical suitability for the exacting conditions and continuous use incidental to the power-service of a copper-reduction works.

When it became necessary to decide the question of power for Nacozari, more than a year's experience of this plant had led to the conclusion that a good gas engine in good condition is a simple and reliable prime-mover, requiring no better class of attendance than steam engines of the same size; and to the further conclusion, that good condition is easily maintained by periodical inspection and cleaning, for which provision must be made.

On consideration of the whole question, with due weight given to the facts briefly indicated above, it was decided that properly selected gas-engines, in a suitably arranged power-plant, would be well adapted to the general conditions at Nacozari, and would give a fuel-economy which was there particularly valuable, in view of the limited local supply of wood and the then necessarily high price of coal.

The power house contains eight single cylinder Crossley gas engines, 18.5 ins. diameter by 24 ins. stroke, running at 200 revs. per min. Each engine is direct belted to a 65-KW. direct current generator. The generators are run in parallel, and deliver to the main switchboard in the power house, from which the current is distributed at 250 volts to some 40 different motors scattered about the works, ranging in size from 5 HP. to 175 HP. Arc and incandescent lights are operated from the same circuit as the motors.

The engines are started by compressed air, a method which has been found very simple and convenient. The cock opening and shutting off the admission of compressed air to the engine cylinder is worked by hand. Frequently but one impulse with compressed air is needed, and seldom more than three.

One air reservoir of 90 cu. ft. capacity is used, which is kept full of air at about 90 lbs. pressure by the intermittent use of a motor-driven air compressor, of 8 ins. diameter by 6 ins. stroke, running at about 60 revolutions per minute. A steam-driven locomotive air pump was used in starting up the plant, and, supplied by the gas-plant boiler, it remains as a stand-by to the compressor.

Opposite each engine is a tank 11 ft. × 18 ft. × 3 ft. deep, which is placed outside of the power-house on a level 20 ft. above the engine. Pipes from the inlet and outlet of the engine water-jacket are connected to the bottom of the tank; and the heat of the cylinder automatically keeps the jacket-water in circulation. The flat form of tank gives sufficient surface to cool the water by radiation and evaporation.

Although this method is automatic and requires no power, it is questionable whether it would not be better to admit the water positively from a storage tank and expend power to pump back to the tank over a cooling tower; since a definite control of the jacket-water is useful when the engines are being driven hard. The question is one for decision according to the conditions of each case.

The water at Nacozari is very hard, and the formation of scale in the water-jackets of the engines caused some trouble at first. The water needed to make up for evaporation is now purified by treatment with soda. It flows from the mixing tank to a deep conical bottom tank, of the type used in the mill for thickening pulp. The sludge of lime and magnesia precipitates escapes at the bottom outlet, while the clarified water, overflowing the rim, passes to the jacket-water tanks.

The main bearings of the engines are oiled continuously by an automatic oil-circulating and filtering system. Two men on shift are required for attendance, an engineer and a helper.

The gas producers are those of the Loomis-Pettibone Gas Machinery Co. The draft through the producers is created by the suction of the gas exhauster, and air enters through the open feed-doors in the top of the producers. Through the same doors the fuel is charged by hand. The air thus comes into contact first with the fresh fuel, and the products of combustion, together with any distillates from the fresh fuel, are drawn downwards through the deep charge of incandescent fuel and out through the fire-brick grate at the bottom of the producer. The high temperature of the gas drawn out of the producer is partially utilized to generate steam in the boiler, through which the gas next passes, and from which it emerges cooled to about the ordinary temperature of chimney gases. It is further cooled to about atmospheric temperature in passing through the water-sprayed coke-filled trays of the scrubber, from which it finally reaches the exhauster which delivers it into the holders.

A gas holder of 15,000 cu. ft. capacity receives the gas which is to be used in the engines, and gives the necessary elastic storage between the production in the gas house and the consumption in the power house. A second gas holder of 5,000 cu. ft. capacity is used to receive, and to keep separate, the water gas made by the intermittent runs.

The producers have 6 ft. 9 ins. inside diameter; and when charged with coal to the highest level practicable they hold a fuel-charge 8 ft. deep. A generating set consists of two producers and one boiler. At Nacozari there are two generating sets which deliver to a common scrubber and a common exhauster, with space provided for the addition of a second scrubber and a second exhauster if desired in the future. The sets are alternated in use. One is run till the accumulation of ash or clinker begins to limit its capacity; the other set is then fired, and blown to incandescence by a centrifugal exhaust fan. The valve connecting the new set to the scrubber and exhauster is opened, and the valve connecting the old set is closed. There is no interruption to the process of gas making. By means of the cleaning doors at the grate level, the producers of the old set are then emptied, and cleaned of ash and clinker. The cleaning doors are closed and sealed air-tight, and the producers charged with fuel ready to fire up again when their turn comes. The length of run on one set depends on the rate of gas making and on the

FIG. 6. POURING THE LEAD INTO A FLEXIBLE JOINT.

percentage of ash in the fuel. At the rate of gas production required for an average load of 600 B. HP., about 80 tons of the ordinary western coal, or about the same weight of wood, may be gasified before the accumulation of ash and clinker necessitates cleaning.

The water used in the scrubber is caught in a lower tank, and pumped back over a small cooling tower to the head tank supplying the scrubber. The feed-water for the boiler is drawn from the supply already purified by soda treatment for use in the engine jackets.

With fuel delivered in the gas house bins, the attendance required is one gas maker and one helper on each shift, and extra labor for cleaning the producers.

METHOD OF MAKING GAS.

In the Loomis-Pettibone producers, as ordinarily used with the object of making as much water gas as possible, the aim is to get the fires very hot before making water gas, and to continue the admission of steam until the fires are cooled to a point where a considerable portion of the steam passes through unaltered; the making of producer gas with air is then resumed, with the aim of quickly blowing the fires as hot as possible, preparatory to steaming them again to make water gas. This procedure necessarily causes great variation in the temperature of the fires, and this, though it has little effect on the quality of the water gas, has a very great effect on the quality of the producer gas, since the latter, when made by blowing a cold fire, has a large percentage of CO_2 and is lean in the combustible CO; while with a hot fire, the percentage of CO_2 is very much less, and that of CO more than correspondingly increased,—one volume of CO_2 being converted into two volumes of CO.

The original intention was to make producer gas and water gas at Nacozari in the usual manner by alternate blowing and steaming, the two kinds of gas to be delivered into two separate holders, and from these drawn in definite proportions through a mixing valve into the gas main leading to the engines. In a large plant, making gas from several sets of producers simultaneously, this mode of operation would doubtless deliver to the engines a sufficiently uniform quality of mixed gas, because the variation in quality of producer gas from one set would be averaged in the holder by the gases from the other sets, which would never be simultaneously at the same stage of temperature; but in a plant operating only one set of producers, as at Nacozari, the quality of the mixed gas was too variable. The method of gas making was therefore modified to avoid great variations in the temperature of the fires. The steam pipe connections permit the introduction of steam together with the air to the top of the fire, and by this means the excess heat of the fire caused by the air blowing may be concurrently used to make water gas; so that by properly proportioning the quantities of steam and air introduced, the fires may be maintained at a practically uniform temperature for a long period of time. As a matter of fact, at Morenci, Ariz., where the Detroit Copper Mining Co. operated an identical gas plant, at times when the load was very uniform, runs have been made in this manner without touching a valve for 24 hours. Obviously, however, such a state of equilibrium requires an adjustment of air and steam rather too fine for easy every-day working. The method preferred, therefore, is to admit somewhat less top steam than could be used, in order to allow the fire to increase slowly in temperature; and then, without allowing the temperature to become excessive, to make a short water-gas run which only slightly cools the fire, and to resume immediately the making of mixed gas with top steam. By this method the fire is never allowed to become cold enough to make an undue proportion of CO_2 and its maximum and minimum temperatures vary but slightly from an average high temperature.

In addition to the fact that this method obviates the necessity of nice adjustment, the occasional water gas runs (alternately up and down the producers as previously described in this paper) have a very beneficial effect upon the fire. They distribute the heat more uniformly throughout the column of fuel, and in a manner shake it up and thus prevent the formation of holes or masses of clinker.

The water gas made separately by this method and delivered into the water-gas holder is gradually fed from the latter into the main holder which supplies the gas engines, the water-gas holder being weighed to give an inch or two greater pressure than that of the main holder. The rate of feed is controlled by a throttle valve, in a pipe connecting the two holders, which the operator manipulates so that the rate of feeding water gas approximately equals the rate of its production. No particular accuracy is required, nor are pains taken to regulate the quantity of water gas made separately. The operator is governed principally by the temperature of the fire, as indicated by its appearance and by the rise of steam pressure in the boiler. If the fall of the water-gas holder necessitates the making of water gas before the fires seem quite hot enough, the throttle valve opening is slightly lessened, and vice versa. This is not a point which varies much during the day, or even from day to day, further than that, at the beginning of a run on a new set of generators, the production of water gas may differ from the quantity made several days later at the conclusion of the run on the same set.

By this method it has been found quite easy to make such gas, that the variations in its quality, shown by analyses and calorimetric readings, have no observable effect upon the working of the engines or upon their efficiency.

Gas for power must be of uniform quality; and a plant whose product is used for power alone must make uniform gas at varying rates. To do this with greatest economy all gas must be made of the same quality, that there may be no need of wasting lean gas through the purge-valve. The method used at Nacozari seems well adapted to this condition. The fall of the main holder during the 3 or 4 minutes occupied in putting water gas into the separate holder is compensated by its rise during the interval between water gas runs. The production is set sufficiently in excess of the consumption to effect this compensation; and under a steady load, the position of the holder ranges between the same index-marks with great regularity. But with a change in the power demand lasting for some time, the rise of the holder ceases to equal its fall. This discrepancy is met by changing the quantities of air and steam without altering their ratio, and by a corresponding change in the interval between the water gas runs. The result is that the time occupied by one cycle of operations is shortened for an increased, and lengthened for a decreased, demand. Nevertheless, coal, air and steam are consumed in the same ratio as before, and in constant quantities per cycle. Consequently, the range of temperature in the fire remains unchanged, and the proportion of top-steam gas to separate water gas is approximately the same. This method therefore gives, at all rates of production, those nearly uniform conditions in the fire which are of the first importance for making gas of uniform quality.

GAS MADE FROM WOOD.

The most novel feature of the Nacozari power plant is the use of producer gas made from wood alone. No guiding experience was found for this process; but, with the desire to utilize as far as possible the limited local wood supply, the gas producer plant was selected with the object, among other things, of determining the advisability of using, if not wood alone, at least a considerable mixture of wood with bituminous coal. The power plant was started in operation July 31, 1900, with coal; but for some months there was no convenient opportunity to experiment with wood, and it was not until February 1901, that the first trial of wood alone was made.

The most obvious difficulty to be feared arose from the large proportion of condensible distillates yielded by wood and the danger that some portion of these might be imperfectly fixed in passing through the producer. The trouble from tar deposited in the gas apparatus and pipes would be serious, and even a small quantity of tar in the gas itself is a fertile source of trouble at the engine valves. Unless a permanent gas could be made from wood, the fuel would be unavailable.

The first care, therefore, was to insure that there should be a bed of charcoal on the grate sufficient to form an adequate fixing zone. To obtain this the producers were filled about 5 ft. deep with cordwood sawn in blocks about 6 ins. long, and the contents blown with a slow fire for four or five hours before the gas was turned into the holder. The gas, as it proved, was turned into the holder too soon. At first, it contained some tar; and it was not until after about three hours' operation that the charcoal accumulated in sufficient quantity so that the producers delivered fixed permanent gases to the holder. This was evident on exposing white paper to the gas, and is also clearly indicated in the series of calorimetric readings which were begun one hour after the gas was turned into the holder. The high calorific values of the first readings, gradually diminishing to the nearly uniform values which correspond with the results subsequently obtained, mark the disappearance of partially condensible distillates.

This preliminary trial lasted more than twelve hours, until the supply of sawed wood was exhausted. As was expected, upon drawing the fires a considerable quantity of charcoal was obtained, which was available for use as a bed in starting the succeeding fires. But before the next trial was made it was suggested that for this purpose coke would be better than charcoal. Although in the first trial charcoal in sufficient quantity had proved effective in fixing all of the gases, it was felt, rightly or wrongly, that the coke would be a stouter and more reliable screen than the comparatively frail charcoal; and in particular, that, as a reinforcement to the charcoal formed above it by the action of the fire, it would effectually safeguard against the possible danger that temporary holes might be burned through the charcoal, by which tar vapors might escape from the producer, but for the fixing action of the more enduring coke. However correct this opinion might be, a coke-bed would certainly be an additional precaution against the serious trouble which might result from delivering imperfectly fixed gases to the holder and would give to the operator great relief from anxiety on this score. It was therefore thought best without further experiment to use coke, which was available at Nacozari; and the practice has been continued ever since. The experience at Nacozari, therefore, does not determine whether it would be safe to dispense with the use of coke.

The second trial, beginning March 14, was carried on for 66 hours with perfect success; and after a third trial of 36 hours' duration, made a few days later, had proved that there was no difficulty in repeating the previous excellent results, measures were taken to gather a supply of wood sufficient to operate the plant with wood gas exclusively.

The average analysis and calorific value of wood gas made during the second and third trials are as follows: CO, 21.6%; H, 12.68%; CH_4, 1.80%; C_nH_{2n}, 0.18%; CO_2, 8.1%; O, 0.2%; N, 55.38%; 131.1, B. T. U. per cu. ft. at 60° F. and 29.9 ins. barometer.

The wood used for the first trial was sawn needlessly small. For the second trial the bulk of the wood was in half lengths of cordwood, with about 10% whole lengths and 10% short blocks. The producers at Nacozari are too small to use whole length cordwood alone. Half lengths are satisfactory for fuel, but small sticks may be quickly sawn into 6-in. lengths, giving a stock of small blocks for filling holes or quickly building up the fires. The wood is cut for packing on burros, and is little more than 3 ft. long; there is also a large proportion of crooked sticks. As actually piled in the yard and paid for, it weighs about 2,200 lbs. per cord. A motor driven, semi-portable circular saw frame, which may be shifted along the wood pile, will handle 14 cords in 10 hours, with one cut to the stick and small stuff into short blocks. This is equivalent to more than 3,000 lbs. per hour.

The wood used is principally scrub white oak, with about 10% ash. The moisture averages 19¼%.

Ordinarily, no top steam is used in making wood gas, the contained moisture taking its place. Drier wood, without top steam, means somewhat more frequent water gas runs. With very wet wood the fires do not become hot enough to make good gas. About 3 ft. depth of coke is put in to form the precautionary bed, the greater part of which is recovered

REMARKS ON THE USE OF GAS ENGINES.

The sustained capacity and satisfactory working of a gas engine depend on its being kept in thoroughly good

FIG. 7. LIFTING 24-IN. FLEXIBLE-PIPE AT TONAWANDA; SHOWING THE 6-IN. PIPE ROLLERS FOR WINDING UP LIFTING ROPES.

condition. The principal meaning of "good condition" is, that the valves should seat freely, and be tight when seated; and that the inside of the cylinder should not be foul with carbonized oil. Leaky or sticky valves and dirty cylinders are the causes of nine-tenths of the ills peculiar to gas engines. A gas valve sticking open may cause the engine to run away; but, with this one exception, every other trouble manifests itself by reducing the capacity of the engine, or by bringing it to an actual stop. Hence good condition is essential to satisfactory operation. It is easily maintained by periodical attention—cleaning the cylinders, slightly regrinding the valves to their seats, and a care of the igniters, which differs according to the type of igniter used.

This general examination should be made methodically and at regular periods, after the engine has been running a certain number of hours, as determined by experience in each plant. It cannot be deferred indefinitely, to suit occasional shut-downs, without danger of the engine giving trouble; and it necessitates shutting down from one to three hours. Where reliable or continuous service is necessary, the required opportunity and leisure for periodical inspection can be obtained only by having a spare unit in each group of gas engines. It is hardly too much to say that this is the one essential feature in planning a gas engine plant which constitutes the difference between a plant which will be thoroughly satisfactory in operation and one which will be eminently unsatisfactory.

The rated capacity of a steam engine being approximately at that point of cut-off where it uses steam most economically, there is always available a considerable reserve capacity, at the expense of economy, by admitting steam for nearly full stroke. The most economical capacity of a gas engine is its absolute maximum capacity, when at every admission it takes the maximum quantity of mixture, in the best proportions of air and gas, and ignites it at exactly the right point. The adjustments necessary to obtain all these conditions with certainty at every stroke, are too fine for any but test conditions. To allow for variations, which are inevitable, even under the best conditions in commercial working, the maximum capacity should be discounted about 15% to get a figure which may be called "maximum commercial capacity;" and nothing more than this latter figure should be counted upon for those short periods which occur, even with the most uniform load, when the load rises to a maximum greater than the average. In other words, this commercial maximum capacity should equal the peak of the load curve. With a very variable load, therefore, an engine capacity is required greatly in excess of the average power demand; and any method of averaging the power variations of individual loads by driving several such loads from one group of engines will reduce the total engine capacity to be installed. The central power house plan with electrical distribution, is, therefore, one which is well worthy of careful consideration for at least some portion of any gas power plant, in spite of the heavy tax to be paid in transformation and transmission losses, losses in the electric generator, the line and the motor, which practically amount to 25% of the B. HP. delivered by the engines.

When the original load on a gas engine which is belted directly to the shafting, outgrows the capacity of the engine, it is generally difficult to devise satisfactory means of supplementing the engine-power. There is a fixed charge of cost and trouble attaching to each engine, irrespective of its size, which makes it undesirable to use engines much smaller than the average size. This is frequently a hampering condition. Gas engines are not self starting, and cannot be started with the load on. Tight and loose pulleys will answer for small engines, but those of more than moderate power need clutch pulleys on the shafting. They need good foundations, and occupy a floor space large in comparison with their power. Additions generally require floor or shafting space which is not conveniently available. And furthermore, when several engines are driving directly on the same shaft, it is difficult to be certain that the proportion of gas to air, and other adjustments, are so regulated that each cylinder is doing its full share of the work. In fact it may be taken as certain that the combined capacity obtained from such a group of engines will not be equal to the sum of their individual capacities. In their adaptability to meet changing power demands gas engines are much less flexible than are steam engines.

The ease with which gas may be transmitted to scattered points without loss, and the heavy power loss involved in transforming and transmitting the power by electric distribution, at first sight makes it appear as though the advantages of using scattered gas engines, directly connected to the shafting, would far outweigh any benefits obtainable by electric distribution from gas engines concentrated in a power house. But when the peculiarities of the engines themselves are considered, in many, not to say most cases, the balance of advantage is found to be on the side of electrical distribution, notwithstanding the cost of electrical apparatus and the constant electrical loss of 25% of the power delivered by the engines.

Gas engines need an attendant always within easy reach, and preferably always on the spot; their concentration in a central power station therefore largely reduces the cost of attendance. The central station gives all the advantages attached to having all engines of the same size. Growth is by additional units. Spare engines for maintenance, the necessity of which has been previously dwelt upon, are minimized; since one spare unit in the central station gives that freedom for repairs, which, with scattered engines, is obtainable only by having a spare unit at every group where reliable service is essential. The variations of individual loads are averaged in the central power station, so that its load factor, i. e., the percentage which the average is of the maximum load, is the greatest the character of the whole plant will permit. This reduces to the lowest possible figure the proportion of reserve to total engine capacity, as compared with isolated engines or groups of engines, each of which must contain in itself all the reserve capacity required for the variation of its individual load. And, finally, electrical connection is an ideal mode of coupling gas engines together. It dispenses with all shafting and clutches, while the ampere meter on each generator gives the engine man a perfect measure of the work each engine is doing, and so allows him to adjust them for the best individual results.

At points of power-consumption, the mechanical characteristics of electric motors are in striking contrast to those of scattered gas engines. Motors of any size may be used appropriate to the work to be done. They are compact, and need no other foundation than a stiff floor. The motor does its work without attendance, and is easily stopped and started by any workman. It is probably the most robust of all forms of driving machines, and will stand an extraordinary amount of abuse and neglect without serious damage, and with nearly unimpaired efficiency. It has a large temporary reserve capacity in excess of its rating, and varies little in efficiency from light load to overload. And if a local increase of power is needed, generally two or three hours' work is all that is required to supplement a motor with a smaller one, or replace it by one of greater capacity.

Each plant and locality presents its own problems, which must be individually considered and suitably met. The question of concentrated versus scattered gas engines admits of no sweeping decision. For those scattered points of a plant where the loads are small in amount or very variable in character, and for points where the loads are liable to considerable change in course of time, electrical distribution is certainly preferable. But if at some point there is a load of uniform character and permanent quantity, and of such amount that the number of engines required justifies a spare unit and gives reasonably economical cost of attendance, the balance of advantage will almost certainly be in favor of using at this point of consumption engines directly belted to the shafting. Between these two extremes will always lie a debatable ground where the decision must rest, not upon calculation, but upon judgment.

SOME RECENT WORKS OF RAILWAY TUNNEL IMPROVEMENT.

Railway improvement work involving alterations to tunnels is usually difficult and often dangerous, and it requires much ingenuity and care to carry on the work, so as not to interfere with the traffic and not to endanger the safety of both passengers and workmen. Many old tunnels have had to be relined, and in not a few cases tunnels have been opened up and converted into open cuts. A number of instances of work of this kind have been described in our columns from time to time, and in the present article we include the relining and change of grade in one tunnel and the opening up of another.

WINSTON TUNNEL: CHICAGO GREAT WESTERN RAILWAY.

A difficult piece of work recently completed on the Chicago Great Western Railway was the relining of the Winston tunnel and lowering the grade, while the line was kept in operation. It is a single track tunnel, 2,440 feet long, situated about 20 miles east of Dubuque, Ia. It is built through a stratum of hard blue shale. There is a layer of limestone some distance above the line of the tunnel, and the original builders supposed it was to be in solid rock. This shale is quite hard when first exposed, but decomposes rapidly in the presence of air and water.

The tunnel was built about 18 years ago by Winston Brothers, and was lined entirely with wood. The original arches were made of 12 x 12 in. timbers, 4 ft. apart. As these showed

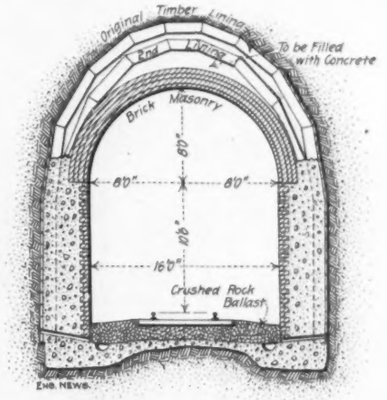


Fig. 1. Cross-Section of Winston Tunnel; Chicago Great Western Ry.
(Showing two timber linings and new concrete lining.)

signs of decay, other timber arches were placed beneath them until finally there was a complete double lining of 12 x 12 in. timber arches, spaced from one to four feet apart in different parts of the tunnel. This is shown in the cross section, Fig. 1.

In order to effect a permanent improvement, and to avoid further trouble or danger, the railway company decided to reline the tunnel with brick and concrete. The plan called for the lowering of the track sufficiently to allow the roof timbers to be left in place, as shown in the profile, Fig. 2. The original intention was to entirely remove the front and back rows of plumb posts, and to fill in with rubble backing and concrete. This, however, proved impracticable owing to the treacherous nature of the material back of the posts, and it was decided to remove the front row only and to leave the back row (and lagging) undisturbed. By so doing it was possible to get

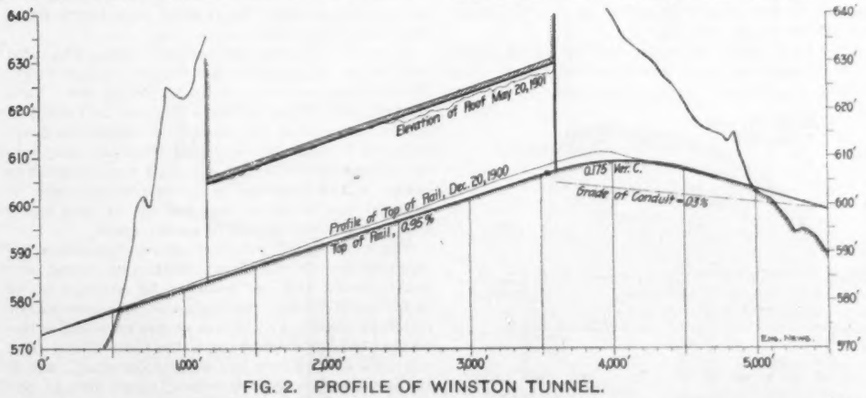


FIG. 2. PROFILE OF WINSTON TUNNEL.

a wall of concrete 3 ft. thick, which was amply sufficient (Fig. 1).

The wall was built of Portland cement concrete and faced with vitrified brick. In order to remove the plumb posts, an 8 x 12 in. sill or straining beam was first notched in on the No. 1 pieces of the timber arches and drift-bolted. Then posts 10 x 10 ins. were placed about 4 ft. apart on a batter, so as to clear the foundation excavation and also clear the passing trains. There was just room for these posts. The plumb posts were then removed, and the foundation trench for the wall was dug. It was necessary to

undermine the back posts in getting the foundation to the required grade, and in several instances slides occurred which delayed the work somewhat, but not seriously.

Both walls being finished to the springing line, the lowering of the track was undertaken. Figs. 3 and 4 show the side wall work in progress and completed.

The track was lowered from one to three feet for a distance of 4,000 feet through the tunnel and passed up through a trap door. The bricks were tossed directly from the cars to the working platform, as they were needed. The arch consisted of a complete semicircle of 8-ft. radius.

The centering consisted of T-iron ribs 4 × 4 × ⅛ ins. bent to a radius of 7 ft. 9½ ins., so as to allow for 2½ inches lagging. These centers were spaced 5 ft. apart and supported on posts, wedges being used to bring them to exact position. There were 40 of these ribs used, which

by Mr. A. Munster, Bridge Engineer, and Mr. H. Potter, Resident Engineer. The contract was given to the Lorimer & Gallagher Company, Chicago; and Mr. W. T. Keating was their superintendent on the work.

ARION TUNNEL; NORFOLK & WESTERN RAILWAY.

The tunnel, which was referred to above as having been converted into an open cut, was the Arion tunnel, about twelve miles west of Po-

FIG. 3. BUILDING NEW SIDE WALLS OF WINSTON TUNNEL.

FIG. 5. PORTION OF WINSTON TUNNEL SHOWING SECTION WITH COMPLETED LINING AND CAR CARRYING STAGING FOR MASONS' USE.

approaches. Owing to the heavy traffic this work proved very tedious and expensive. The track was taken in stretches of 150 feet, and gradually worked down to subgrade, a run-off being kept in shape at the end of the work for the passage of trains. In the tunnel a 6-in. layer of concrete was placed from wall to wall under the ballast, in order to seal out all water and mud. Outside of the tunnel 12 inches of crushed rock was placed under the ties.

After the track lowering was complete, and track brought to final grade with ballast, the arching was begun. A four-ring brick arch was

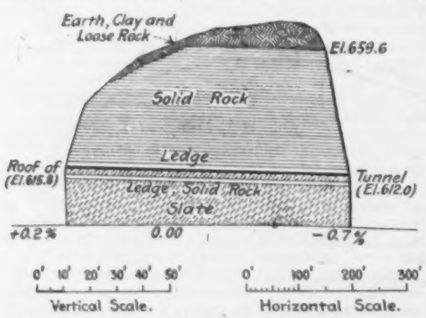


Fig. 7. Profile of Arion Tunnel; Norfolk & Western Ry.

built underneath the roof timbers, and the space between the timbers and the brick arch was packed solidly with concrete. The arching was all done on top of platform cars built especially for the purpose, and Fig. 5 is a view of the work in progress.

The platform was raised about 18 inches above the springing line of the arch. The mortar mixing was done on the floor of the car, and the mortar allowed 200 lin. ft. of arch to be under construction at a time. It was necessary to have a considerable length of working face, so that bricking and back-filling with concrete would be carried on without interference.

The arch was carried up about two feet at a time in benches of 40 to 50 ft. in length. When a stretch was completed and sufficient time had elapsed for setting, the centers were taken down and moved forward.

A large amount of outside work was also carried on in connection with the tunnel work. Heavy dry masonry retaining walls were built on each side of the cut for a distance of 1,000 feet at the east end of the tunnel. A 24-in. tile drain was laid in concrete extending from the east portal to the east end of the cut. This was designed to carry off the drainage of a considerable area of country which drains into the cut at this point. Fig. 6 shows the details of portal work.

The entire work required almost two years for completion, the greatest hindrance being the heavy traffic and the smoke. An average of 12 to 15 trains during working hours was common in the busy season, and in wet or heavy weather the smoke and gas would hang in the tunnel for a considerable time. There is a ventilating shaft, but it has comparatively little effect, partly due to the fact that its top is nearly 100 feet below the crest of the hill. During the work above described a fan was installed at the shaft, but even this did not succeed in clearing the tunnel promptly.

The work was carried to completion without serious accident, and practically without interference with the business of the railway company. About 15,000 barrels of Medusa and Lehigh cement and 11,000 cubic yards of gravel were used for the concrete, also 2,500,000 brick for the facing and lining, etc. The work was done under the direction of Mr. F. R. Coates, M. Am. Soc. C. E., at that time Chief Engineer. He was assisted

mouth, Ohio, on the Norfolk & Western Railway for what was formerly the Cincinnati, Portsmouth & Virginia Railway). Fig. 7 is a profile, and Fig. 8 is a cross section of the tunnel and cut. The tunnel was both too narrow and too low, and the roof was also in bad condition, and it had never been fully lined either by masonry or by timber, the timber lining being in short sections. The problem which presented itself was

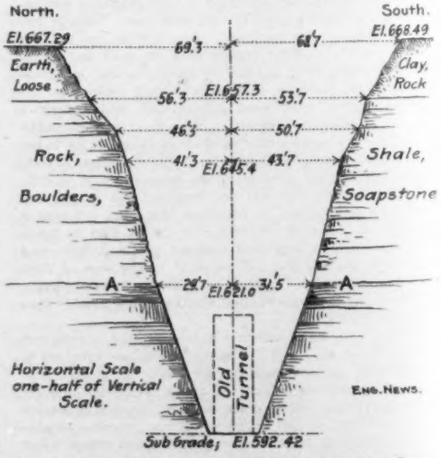


Fig. 8. Cross-Section of Old Tunnel and New Open Cut.

whether to enlarge the section of the tunnel and line it, or to remove the tunnel entirely. After a full examination of the character of the material to be handled and all the conditions connected therewith, and further taking into consideration the fact that there was only one tunnel between

Portsmouth and Cincinnati, it was concluded that in the long run it would be cheaper to take this out as an open cut (although its height was 75 feet) rather than try to enlarge the tunnel and line it. A more thorough knowledge of the character of the material acquired during the progress of work demonstrated the wisdom of this conclusion.

FIG. 4. BUILDING NEW ARCH OF WINSTON TUNNEL.
(The working platform is carried above box cars, in which the mortar mixing is done.)

In excavating, the material was taken off in lifts and hauled both east and west, and when the excavation has been carried down to about the level A-A shown on Fig. 8, the blasting was so done as to cut off gradually the ends of the tunnel, the removal of the ends of the tunnel being for very short sections at a time, and, of course, between trains, so as not to block traffic.

It may be stated in this connection that the railway has followed this same course in removing three other short tunnels on this road in the last four years. For information respecting the above we are indebted to Mr. Charles S. Churchill, M. Am. Soc. C. E., Chief Engineer, Norfolk & Western Railway.

THE DRAFT OF VESSELS IN MOTION IN SHALLOW CHANNELS COMPARED WITH THEIR STATIONARY DRAFT.*

By Henry N. Babcock,† M. Am. Soc. C. E.

The writer submits herewith a record of observations upon the actual draft of large steamships when under way, as compared with their draft at their piers, made in connection with the improvement of channels in New York Harbor, together with some inferences drawn from the results.

The connection with the harbor improvements appears in this way: Notices have been sent to this office, not infrequently, that steamships have touched bottom in the channels, when their draft was less than the presumed channel depth (30 ft. at mean low water). The localities have always been examined: in some cases, small shoals have been found, but generally the soundings have shown a full depth of 30 ft. or over. Several of the reports state that the ship touched bottom, slowed up slightly and passed over, without the occurrence being noticed on the decks, though more or less plain in the engine room, and that no damage was sustained. The occasions were as often in clear daylight and still weather as under other conditions, and it was hardly possible to assume enough carelessness or bad faith to account for them. Preliminary examination with the small steamers under control of this office showed that there existed a noticeable increase of draft due to motion, especially in shallow water. Therefore, it was decided to make actual instrumental observations on the larger steamships, and determine, as closely as might be, how they are affected; for, if the channels 30 ft. deep are not available for vessels drawing nearly, but less than 30 ft., it is important to know it.

METHODS OF OBSERVATION.

The simplest method is to set up a level instrument on shore, to attach gage rods at the bow and stern of the steamer, and take one reading while she is at rest in front of the level, and another as she steams past under full speed. This was done with the engineer steamers, but the large ocean vessels could not be expected to afford opportunities for such observations. For the latter ships, a white mark was painted on the bow and stern at a known draft, generally about 38 ft. above the keel. Transits were stationed at certain fixed points, and as the ship passed, the horizontal cross-hair was clamped at the white mark. A few seconds later, and as soon as the water was quiet, a small boat followed in the ship's wake, carrying a gage-board, with zero set at the water level. The reading of the cross-hair on the gage, deducted from the height of the white mark, gave the draft of the ship in motion below the plane of the undisturbed water. The draft at rest was read just before the ship left the pier.

Three observation stations were used—one at Fort Wadsworth, where the channel is 80 ft. deep or more; one on the West Bank Lighthouse, where the channel is from 31 to 32.5 ft. deep; one at the point of Sandy Hook, where, on a line about northwest from the station, the depths in the usual channel range from 31 to 34.5 ft. The last two are the only points along the shallower parts of the channel where the steamships pass within a mile of a possible instrument station.

At Fort Wadsworth and Sandy Hook, the method was varied by using a level instrument at a known height above the water and reading directly on the draft marks of certain ships, which marks were extended above ordinary drafts for this purpose. This could not be done at West Bank, because the lowest possible instrument station was too high to read any marks which could be placed upon the stern of the ship.

An attempt was made, also, to use vertical angles read to the marks on the ships, determining the distance out by cut-off angles from another station. The nearest point to the West Bank Lighthouse where such cut-off angles could be read is so far distant that a clear air is necessary, in order to see signals and read intersecting angles at the same instant. On the first trial a slight fog interfered with the work, and the plan was dropped for the time.

LIMITS OF ACCURACY.

The chief source of error is in reading the gage (on days when the water is not still) on the small steamer (about 100 ft. long), which follows up the ships. This has been eliminated as far as may be by confining observations to days when the sea is comparatively smooth, with a swell not exceeding 3 ft.; then the gage can be read with a probable error of less than 6 ins. On several days the sea has been calm and this error is reduced to less than 2 ins. at the lower stations; at Fort Wadsworth, further up the harbor, it is

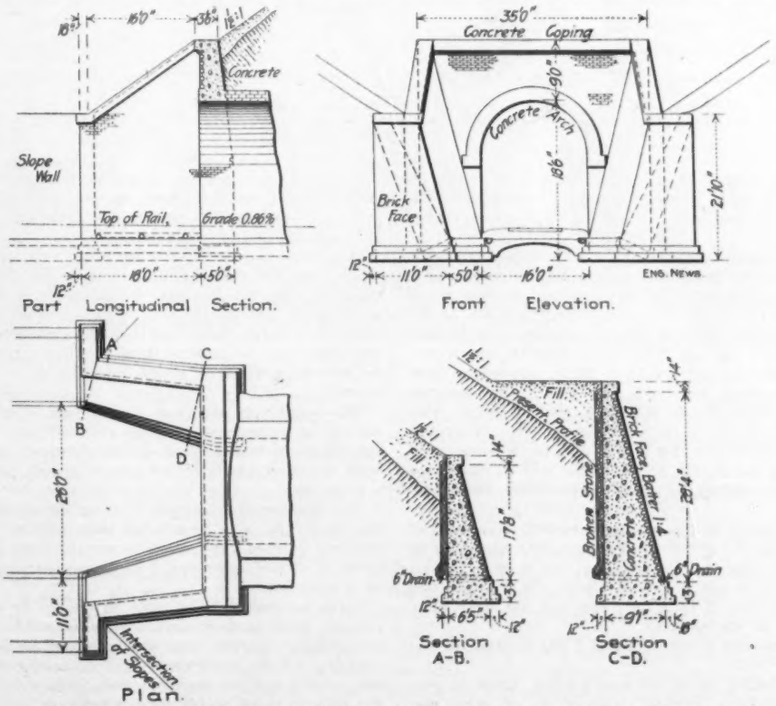


FIG. 6. EAST PORTAL OF WINSTON TUNNEL; CHICAGO GREAT WESTERN RY.

*A report presented to Col. W. L. Marshall, Corps of Engineers, U. S. A.

†U. S. Assistant Engineer, Army Building, New York City.

TABLE I.—RECORD OF OBSERVATIONS OF DRAFT OF VESSELS.

Off Fort Wadsworth: Ships follow a deep channel, with depth from 80 to 100 ft.
Off West Bank Lighthouse: Channel depths are from 31.1 to 32.5 ft.; deep ships generally run west of the center line where the depth is nearly 32 ft.
Off Sandy Hook: Readings were taken as the ships crossed a line nearly due northwest from the point of the Hook, that being the shallowest channel section; on this line close to the Hook depths are over 40 ft., but on and north of the center channel range (the usual sailing course), they vary between 31.0 and 34.5 ft.

Date, 1904.	Name.		Draft at Pier.	Change of Draft at Ft. Wads.	Change of Draft at W. Bank	Change of Draft at S. Hook	Average Speed—Miles per hour.—Wads. to W. Bank	Average Speed—Miles per hour.—W. Bank to Hook.
May 7	Vaderland	for'd	25.6	+ 0.6	.....	.....	16.2	....
		aft	26.1	— 0.3	+ 3.4	.....	....	....
May 7	Minnetonka	for'd	28.0	+ 0.5	— 2.0	.....	13.8	....
		aft	28.0	+ 1.0	+ 2.9	.....	....	....
May 14	St. Paul	for'd	28.0	+ 1.5	.....	.....	14.4	17.4
		aft	28.7	+ 0.8	+ 3.2	+ 2.5	....	....
May 14	Krooniand	for'd	23.8	.....	— 0.3	.....	14.4	15.8
		aft	24.8	.....	+ 0.5	+ 2.7	(1)	....
May 17	Kaiser Wilhelm II	for'd	30.0	+ 0.3	— 0.7	.....	16.9	....
		aft	30.3	+ 1.3	+ 4.0	.....	....	....
May 17	Rotterdam	for'd	23.3	— 0.1	+ 2.3	.....	19.2	....
		aft	23.3	+ 0.6	+ 2.7	.....	....	....
May 18	Cedric	for'd	29.6	+ 1.4	+ 0.6	.....	11.1	....
		aft	29.6	+ 1.1	+ 2.3	.....	....	....
May 21	Philadelphia	for'd	28.5	+ 1.9	— 1.5	.....	19.2	....
		aft	28.9	+ 1.6	+ 4.4	.....	....	....
May 21	Patricia	for'd	23.7	+ 1.4	.....	.....	11.1	....
		aft	25.7	+ 0.7	+ 2.0	.....	....	....
May 21	Zeeland	for'd	24.8	+ 1.4	+ 3.7	.....	16.0	....
		aft	26.4	+ 0.6	+ 2.9	.....	....	....
May 21	Minneapolis	for'd	26.7	+ 1.7	+ 1.9	.....	16.9	....
		aft	27.5	+ 1.1	+ 3.0	.....	....	....
May 21	Campania	for'd	29.5	+ 1.0	+ 2.0	.....	20.6	(-)
		aft	29.5	+ 1.6	+ 1.0	.....	....	....
May 28	Mesaba	for'd	22.8	.....	.....	+ 0.5	13.7	16.6
		aft	26.6	.....	.....	+ 1.9	....	....
May 28	St. Louis	for'd	28.4	+ 1.6	.....	+ 2.9	15.6	16.2
		aft	28.9	+ 1.1	.....	+ 3.4	....	....
May 28	Finland	for'd	24.3	+ 1.8	.....	+ 1.2	15.2	15.1
		aft	25.2	+ 1.6	.....	+ 1.5	....	....
June 4	Germanic	for'd	25.2	+ 0.7	.....	.....	11.1	19.3
		aft	25.6	+ 1.2	.....	+ 2.0	....	....
June 4	Pretoria	for'd	22.2	+ 1.0	.....	+ 1.5	11.5	14.5
		aft	24.7	+ 0.6	.....	+ 1.1	....	....
June 4	Lucania	for'd	29.5	.....	.....	.....	13.1	23.2
		aft	29.5	+ 0.8	.....	+ 2.9	....	....
June 4	Minnetonka	for'd	26.2	+ 0.8	.....	+ 0.8	12.5	18.4
		aft	27.2	+ 0.8	.....	+ 2.1	....	....
June 4	Vaderland	for'd	25.7	+ 0.1	.....	+ 1.1	13.7	18.4
		aft	26.2	— 0.2	.....	+ 1.5	....	....
June 11	St. Paul	for'd	28.4	+ 1.2	+ 1.1	.....	4.2	(2)
		aft	28.7	+ 0.7	+ 0.8	.....	....	....
June 11	Krooniand	for'd	24.0	+ 0.6	+ 2.0	.....	15.2	....
		aft	26.0	+ 0.8	+ 3.0	.....	....	....
June 18	Philadelphia	for'd	28.3	+ 1.0	.....	+ 2.8	....	20.5
		aft	28.5	+ 1.4	.....	+ 3.6	....	....
June 18	Zeeland	for'd	27.8	+ 0.2	.....	+ 1.6	....	18.2
		aft	28.3	+ 0.2	.....	+ 1.6	....	....
June 25	Mesaba	for'd	19.7	.....	+ 1.7	+ 1.0	14.4	15.8
		aft	26.4	— 0.4	+ 1.4	+ 0.7	....	....
June 25	St. Louis	for'd	28.1	+ 0.7	.....	+ 1.7	16.9	15.5
		aft	28.3	+ 1.2	+ 2.8	+ 2.7	....	....
June 25	Pr. Adalbert	for'd	18.5	.....	+ 2.2	+ 0.6	14.4	16.6
		aft	21.0	+ 0.4	+ 2.9	+ 1.1	....	....
June 25	Finland	for'd	24.6	+ 0.2	+ 2.0	+ 1.5	18.0	14.5
		aft	25.8	+ 0.2	+ 3.4	+ 2.4	....	....
June 25	Etruria	for'd	27.9	.....	.....	.....	14.4	15.7
		aft	27.8	+ 1.2	.....	+ 1.7	....	....
July 2	Patricia	for'd	26.0	.....	+ 1.5	.....	13.3	....
		aft	27.5	.....	+ 1.0	.....	....	....
July 2	Minnetonka	for'd	27.0	+ 0.7	+ 2.4	.....	16.6	....
		aft	27.2	+ 0.5	+ 3.6	.....	....	....
July 2	Germanic	for'd	24.8	+ 0.1	+ 1.4	.....	17.2	....
		aft	25.3	+ 0.6	+ 3.0	.....	....	....
July 2	Lucania	for'd	29.1	+ 0.6	+ 2.4	.....	17.9	....
		aft	29.5	+ 0.6	+ 2.6	.....	....	....
July 2 (4)	Vaderland	for'd	25.8	+ 0.6	+ 3.2	.....	16.9	....
		aft	28.0	+ 0.7	+ 4.0	.....	....	....

[1] At W. Bank, reversed to avoid tow; estimated speed in passing, 4.0.
[2] At W. Bank, nearly stopped in passing K. Albert; estimated speed 8.0.
[3] Very slow, and waiting for a rise of tide before crossing the bar.
[4] Rough sea; readings not accurate.

always more quiet. This source of error is avoided when a direct reading from a level instrument can be had upon the gage marks on the ships.

An occasional liability to error arises from the difficulty in following up the exact course of a ship when that course is changing or when other vessels are in the channel. Thirty feet out of the exact course would presumably be a maximum deviation, and at West Bank Lighthouse, where the observer is from 10 to 20 ft. above the level of the mark observed, and where the distance to the ship's course is from 1,300 to 2,400 ft., this might introduce an error of 0.5 ft. With the level instrument the errors due to inaccuracy of reading the marks on the ships and to curvature of the earth are together probably less than 0.3 ft.

The water in the bay is more salt than that at the piers, the difference varying with the state of the tide and of river freshets. In summer, when the river is low, it would lessen the draft in the bay by from 1 to 3 ins., and has not been considered in the results.

The results given in Table I are exactly as observed.

The hollow under the ship's stern, when in motion, offers a simple explanation of why she should "squat" aft. It is not so apparent why she should squat forward, but a summary of the results in Table II shows that it is almost uniformly the case.

This is corroborated by observations upon the engineer steamers of this district. The observations in Table III were made on July 11, in Gravesend Bay, over a course where the water was from 11 to 12 ft. deep, in still weather and with all conditions favorable for close accuracy.

It appears that the squatting is greater in shoal water than in deep. At West Bank it is greater than at Sandy Hook, and at either point greater than off Fort Wadsworth. It increases with the speed and, not improbably, may vary with the lines of a ship's hull. In the majority of cases the squat aft is greater than forward, and this is especially true in shoal water and at high speed.

The maximum observed "squat" aft is 4.4 ft., occurring in case of a large ship 560 ft. long, traveling at rather high speed in shoal water, with her keel about a foot above bottom and in a calm sea.

The maximum observed settling down of the bow is 3.7 ft., due to a large ship, 580 ft. long, running at moderate speed in shoal water, with her keel at the bow about 6 ft. above bottom, and in a calm sea.

These maxima are so little in excess of other records that they cannot be disregarded; they are probably correct and within moderate limits, perhaps 0.3 ft. accurate. And it seems fairly well shown that in extreme cases large ships under way in shoal water may require at least 4½ ft. more depth in the channel than their draft at the pier indicates.

Care has been taken to avoid the possible changes of draft which would occur if the water ballast were shifted before passing the lowest station, at Sandy Hook.

Acknowledgment is due the agents and officials

TABLE II.—Summary of Observations of Draft of Vessels.

	Forward + No. of observ'ns.	Forward + Average change of draft.	Forward — No. of observ'ns.	Forward — Average change of draft.	Aft + No. of observ'ns.	Aft + Average change of draft.	Aft — No. of observ'ns.	Aft — Average change of draft.
Ft. Wadsworth	26	0.90	1	0.10	28	0.89	3	0.30
West Bank	15	2.03	4	1.12	23	2.64	0	....
Sandy Hook	12	1.45	0	....	17	2.08	0	....
Total, 3 stations	53	1.35	5	0.92	68	1.78	3	0.30

+Indicates a squat or settling below the draft at the pier.
—Indicates a rise or lifting.

of the several steamship lines for their interested assistance and co-operation, without which the observations would have been attended with considerably greater difficulty. In every case without exception, it has been necessary only to explain the nature of the work in order to obtain every facility for carrying it on and such help as could be rendered. The active interest displayed by the survey party under Mr. Glen E. Balch, junior engineer, has also been of the greatest value.

It is proposed to continue these observations from time to time, whenever the party can be detached from other work without undue expense and inconvenience.

DEDUCTIONS FROM OBSERVATIONS.

While the records are not sufficiently complete and extended to afford a basis for very exact deductions, it is hard to resist the temptation to see what inference may be drawn from the information in hand.

Perhaps the most important inference would be in relation to the liability of a ship's touching bottom by reason of her "squat." As might be expected, the data show that the amount of squat is some kind of a direct function of the speed, and of an inverse function of the depth of water below the keel.

Arranging the data obtained in order of the depths below the keel, we have Table IV, in which the limits of depth are determined from soundings across the channel on the line of observation, and the estimated depth is that in the course usually taken by large ships (though the actual depth in any particular case may be anywhere between the limits): in which the speed is the average speed while the ship is passing between different stations, and to which is added the height of waves at the time of observation, as well as the condition of tide, upon which the depths depend.

From this table the ratios existing between the speed and the amount of squat, for different depths of water below the keel, may be examined:

Depths below keel in feet.	Ratios: — miles per hour, divided by squat, in feet.	Average ratio.
0 to 1	4.4	4.4
1 to 2	6.0 — 4.2 — 4.8	5.0
2 to 3	5.4 — 5.3 — 5.2	5.3
3 to 4	4.8 — 5.1 — 6.9	5.6
4 to 5	4.2 — 4.8 — 4.8 — 8.5 — 5.6	5.6
5 to 6	4.6 — 8.0 — 9.2	7.3
6 to 7	5.5 — 8.7 — 10.1 — 5.7 — 8.9 - 5.3	7.4
7 to 8	5.5 — 5.7	5.6
8 to 9	5.0 — 8.8 — 11.4	8.4
9 to 10	9.6	9.6
10 to 11	7.1 — 12.3	9.7
11 to 12	13.2	13.2

These averages show a nearly uninterrupted increase in the ratio between the speed and the squat, as the depth under the keel increases; and the irregularities in the individual ratios are not surprising, considering the limited number of observations and the conditions, as yet unknown, which may have affected them. Indeed, for the lesser depths under the keel, from 1 to 3 ft., the ratio may be assumed as constant, at about 5.0.

In so far as this is accurate, and it appears to be nearly so, it affords a general gage for the speed at which a ship may run without probability of touching the bottom. In New York harbor the present channel depth is 30 ft. at mean low water; a ship loaded to 29.5 ft. draft at the pier, and due to cross the bar when the tide is

TABLE III.—Change of Draft of Small Steamers When Under Way.

Steamer.		Approx. draft at rest.	Change of draft when —at full speed.— 1st. trial	2nd trial	3d trial	Estimated speed.
Manisees	for'd	6.0	+0.85	+0.55	+0.65	10-12 miles
	aft	8.0	+1.45	+1.35	+1.3	
Engineer	for'd	6.0	+0.80	+1.00	.....	10-11 miles
	aft	7.8	+0.80	+1.00	.....	

TABLE IV.—RELATION BETWEEN DEPTH UNDER KEEL, SPEED, AND SQUAT.

Date.	Tide R. = rising F. = falling St. = stand	Name.	Maximum observed draft.	Depth under Keel—Limits of	Depth under Keel—Estimated	Speed miles per hour.	"Squat" (feet)	Height of waves (feet)
May 21	2.2 R	Philadelphia	33.3	0.0 — 1.4	0.9	19.2	4.4	0.5
June 25	0.2 F	St. Louis	31.1	0.2 — 1.6	1.1	16.9	2.8	.0
May 17	4.0 R	Kaiser Wm. II	34.3	0.8 — 2.2	1.7	16.9	4.0	1.5
May 28	0.5 F	St. Louis	32.3	0.8 — 2.7	1.7	16.2	3.4	1.0
May 14	2.0 F	St. Paul	31.9	1.2 — 2.6	2.1	17.4	3.2	0.5
June 25	—0.3 F	Finland	29.2	1.6 — 3.0	2.5	18.0	3.4	.0
June 11	0.4 F	St. Paul	29.5	2.0 — 3.4	2.9	4.2	0.8	2.5
May 18	3.0 R	Cedric	31.9	2.2 — 3.6	3.1	11.1	2.3	1.5
June 11	0.3 St	Kroonland	29.0	2.4 — 3.8	3.3	15.2	3.0	2.5
July 2	3.8 R	Lucania	32.1	2.8 — 4.2	3.7	17.9	2.6	2.0
"	4.0 R	Vaderland	32.0	3.1 — 4.5	4.0	16.9	4.0	3.0
May 7	3.0 R	Minnetonka	30.9	3.2 — 4.6	4.1	13.8	2.9	2.5
"	2.0 R	Vaderland	29.5	3.6 — 5.0	4.5	16.2	3.4	1.0
June 25	0.6 F	Mesaba	27.8	3.9 — 5.3	4.8	14.4	1.7	.0
May 21	3.4 R	Minneapolis	30.5	4.0 — 5.4	4.9	16.9	3.0	1.0
July 2	3.8 R	Minnetonka	30.8	4.1 — 5.5	5.0	16.6	3.6	3.0
June 4	4.3 St	Lucania	32.4	2.9 — 6.4	5.4	23.2	2.9	1.0
June 25	1.2 R	Etruria	29.3	2.9 — 6.4	5.4	15.7	1.7	0.5
May 21	3.4 R	Zeeland	29.3	5.2 — 6.6	6.1	16.0	2.9	1.0
May 28	1.2 F	Mesaba	28.5	3.5 — 7.2	6.2	16.6	1.9	1.0
"	—0.2 F	Finland	26.7	4.1 — 7.6	6.6	15.2	1.5	1.0
June 18	5.3 R	Philadelphia	32.1	4.2 — 7.7	6.7	20.5	3.6	2.0
July 2	3.3 R	Patricia	28.5	5.9 — 7.3	6.8	13.3	1.5	2.5
May 14	0.8 F	Kroonland	27.5	4.3 — 7.8	6.8	14.4	2.7	1.0
May 21	3.0 R	Patricia	27.7	6.4 — 7.8	7.3	11.1	2.0	0.5
July 2	3.8 R	Germanic	28.3	6.6 — 8.0	7.5	17.2	3.0	2.0
June 25	0.0 F	Pr. Adalbert	23.9	7.2 — 8.6	8.1	14.4	2.9	.0
June 4	4.3 St	Minnetonka	29.3	6.0 — 9.5	8.5	18.4	2.1	1.0
June 18	5.3 F	Zeeland	29.9	6.4 — 9.9	8.9	18.2	1.6	2.0
June 4	3.9 R	Germanic	27.6	7.3 — 10.8	9.8	19.3	2.0	1.0
May 17	4.0 F	Rotterdam	26.0	9.1 — 10.5	10.0	19.2	2.7	1.5
June 4	4.3 St	Vaderland	27.8	7.5 — 11.0	10.0	18.4	1.5	1.0
"	4.2 R	Pretoria	25.8	9.4 — 12.9	11.9	14.5	1.1	1.0

2.0 ft. up, may safely squat 2.5 ft., which corresponds to a speed of 12½ miles per hour. As the channel generally is slightly deeper than the project calls for, she may run at somewhat greater speed, but will be taking chances of touching.

Last winter, three cases were reported of ships touching bottom, all in Bayside Channel; the bottom of Bayside Channel is hard sand, and a lighter touch would be felt there than in the Main Ship Channel, where the bottom is ordinarily soft. An examination of the channel made since, shows no depths less than 30.3 ft., and none along the course usually followed less than 31 ft.

On Dec. 5, the "Philadelphia," drawing 29.4 ft., passed through Bayside Channel and touched bottom at 3:40 P. M. The tide was rising and is about 20 minutes earlier at Bayside Channel than at Fort Hamilton. At 4:00 P. M. at Fort Hamilton the tide was 0.0 (low water had been —1.06), which would give a channel depth of 30.0; the probable channel depth at that point is about 1 foot in excess of the projected depth, and would permit of a squat of 1.6 ft., corresponding to a speed of 8 miles per hour. Her speed is generally much greater than this.

March 9, 1904, the "Oceanic," outward bound, touched bottom lightly at 1:31 P. M., about high water; high water at Fort Hamilton that day was 3.06, making the channel depth 33.1 ft. The ship was drawing 30.5 ft. when she left her pier, at 12 o'clock noon. Allowing ten minutes for getting away from her pier and under way, she made the 24 miles from the pier to buoy B1, Bayside Channel, at an average speed of 18 miles per hour; this would give a squat of 3.6 ft. and make her draft at the bar 34.1 ft.

March 30, 1904, the "Oceanic," inward bound, draft 28.3 ft., touched bottom in Bayside Channel at 0:40 o'clock P. M. Low water was predicted at 0:45 P. M., height — 1.0, and it was observed at Governor's Island as about that height. This would make the 30-ft. channel 29.0 ft. deep; the channel in this locality is about a foot deeper than the project calls for, making an available depth of 30 ft. at that tide, allowing a possible squat of 1.7 and speed of 8½ miles before touching bottom. Her speed was probably greater than this.

It is quite likely that many ships touch bottom without reporting it, and perhaps, where the bottom is quite soft, without the ship's officers knowing it.

These observations have been confined to the large transatlantic steamships passing out of New York harbor by the channels made 30 ft. deep at mean low water; the smallest ship upon which the observations were made is 403 ft. long, and all but five of them are over 550 ft. in length. It may be expected, however, that results of the same kind, perhaps different in degree, would be found in cases of other steamships in other waters.

A STEAM SHOVEL TRACK LAYER.

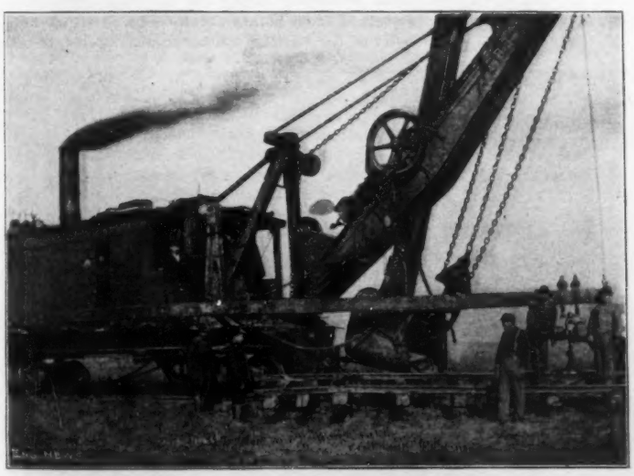
The cost of moving a steam shovel from place to place forms a very considerable part of the total cost of excavating with shovels. With the object of reducing this item of cost, a "track layer" has been invented by Mr. W. B. Michel, to whom patent No. 744,870 has been granted.

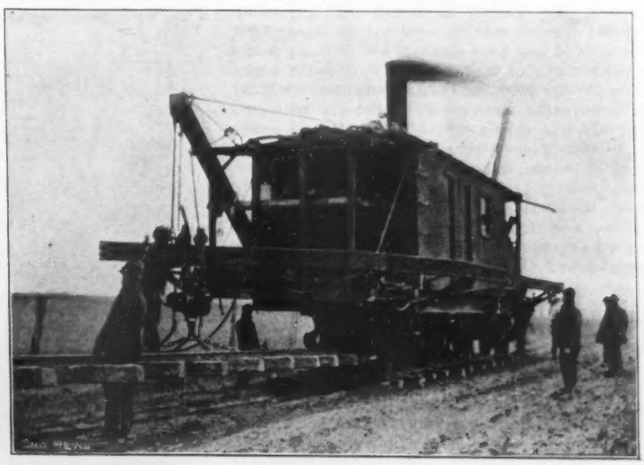
The accompanying cuts show the essential features and the method of using the Michel track layer. It will be seen that there is an I-beam extendin around the shovel car from the rear to the front, the rear end of this I-beam being supported by a boom, and the front end by the shovel boom. The I-beam, which is made in two or three panels, serves as a track for a trolley that is used to support and carry a section of the shovel track. The front panel of the I-beam track is removed when the shovel is digging, but the panels along the side and to the rear are left permanently in place. The trolley is a two-wheel device capable of carrying five tons. A three-ton pneumatic or oscillating hoist, suspended from the trolley, serves to lift a 30-ft. section of shovel track and ties.

The illustration shows a 45-ton shovel making a run of 1,080 ft. in one hour. The same shovel was moved by four men and a horse a distance of half a mile in ten hours over a very soft and muddy road. A 65-ton shovel, using this track layer, was moved 10 miles over country roads, making 12 turns, in 8 days and nights, although during 5 shifts no moving was done. One run of 198 ft. was made in 5 mins., and another run of 1,420 ft. was made in one hour. Another move of five miles was made in six 8-hour days. Still another move of 1,200 ft. in a cut was made in five hours with five laborers. In moving a distance of 13 miles, two-thirds of which was over frozen roads, it was necessary to replace only two ties.

One of the advantages of this method of track moving is that the hoist will lift a section of track even when imbedded in sticky clay. Another advantage is that there is no delay in throwing the loading track when at work in a cut. Under the common method, the entire dump and pit forces may be required to move the shovel back, and finally after a delay of 10 to 15 hours the loading track is thrown and lined up ready to resume work. With this track layer only the pit force is engaged in moving the shovel, while the rest of the force throws the loading track and ballasts it.

For the data of track moving we are indebted to "The Contractor," and for the photographs and other information to Stubbs, Flick & Johnson, Contractors, Granite Block, St. Louis, Mo., from whom further information may be obtained.





A STEAM SHOVEL TRACK LAYER MAKING A 1,080-FT. RUN IN AN HOUR.

SOME FLOOD DISCHARGES AND VALUES OF "n" IN KUTTER'S FORMULA.*

By R. H. Anderson.

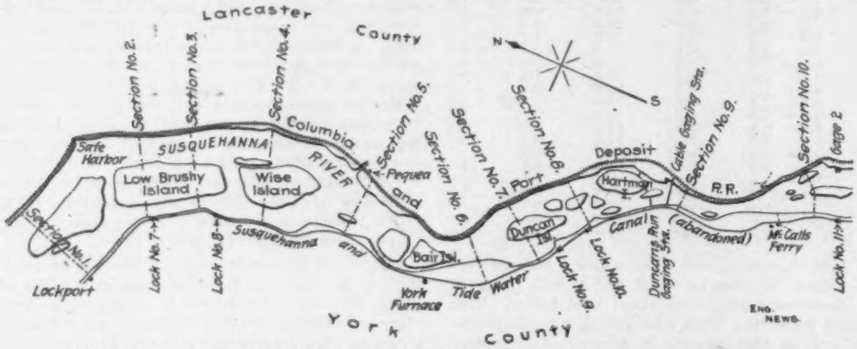
In hydraulic constructions the extent to which provision should be made for extreme floods is often a difficult problem for the engineer, owing to the lack of data in regard to the flow at such times. In some cases, where government records are not at hand, and only low water gagings have been made, the only data available for computing flood discharges are the more or less unreliable high water marks left by the floods or made by the residents in the vicinity. In determining the flow on this basis by the slope formula, two largely uncertain factors generally exist, namely, the slope of the water surface and the coefficient "n" in Kutter's formula.

*Data for these values were furnished through the courtesy of Cary T. Hutchinson, M. Am. Soc. C. E.

TABLE I.—Values of C and N, with Data Used in Their Determination.

Date of Gaging.	Discharge, Second-Feet.	Area, Square Feet.	Wetted Perimeter, Feet.	Hydraulic Radius, R.	Mean Velocity, V, Feet per Second.	Coefficient c.	Observed Slope, s.	Computed Coefficient n.	Remarks.
									El.W. S. 150' above line = 130.72'
									" " 150' below line = 130.30'
July 24, 1902 (a).....	78,300	9,340	560	16.68	8.38	54.9	.0014	.0468	
									Fall in 300'..... = 0.42'
July 26, 1902 (a).....	68,000	8,650	557	15.51	7.86	54.8	.00133	.0462	Fall in 300'..... = 0.40'
June 5, 1903 (a).....	10,000	3,846	380	10.12	2.60	52.3	.000244	.0460	Fall in 900'..... = 0.22'
									Slope between McCall's Ferry and
March 8, 1904 (b).....	631,000	63,400	2,420	26.20	9.96	52.45	.00138	.0545	Gage No. 2.

(a) At Duncan's Run, west portion of Section 7. (b) At Section No. 10.



MAP SHOWING LOCATION OF SECTIONS USED IN COMPUTING FLOOD DISCHARGE OF SUSQUEHANNA RIVER, NEAR McCALL'S FERRY, PA.

The above difficulties were encountered in investigating power development on the Lower Susquehanna River near McCall's Ferry, with which work the writer was connected during 1901-2. The Susquehanna in this region flows with a swift current through an irregular and rocky channel. Its course, in many places, is obstructed by projecting rocks and small islands, and most of the latter are covered with brush or trees.

The highest known flood on the river, unobstructed by ice gorges, occurred in June, 1889. The crest of this flood was marked at many points in the vicinity of McCall's Ferry on posts, rocks, hotels, bridge piers, and canal locks, and as many of these marks were made by the eye witnesses who still live in the neighborhood, it was possible to closely approximate the mean slope for a reach of several miles. A contour map had been made, from which ten measuring sections were chosen, as shown in the accompanying cut. These sections were located, as far as possible, so as to give an average for the portions of the river represented, and so that the mean slope between the nearest reliable high water marks could be used in connection with them. The sections were carefully surveyed and sounded so as to accurately determine their area and wetted perimeter. Further experience with minor floods showed that more satisfactory results could be obtained by thus taking average sections with the fall in several thousand feet than by trying to get an accurate slope at a less representative point where only a short distance could be used for the water surface levels.

Figs. 3 and 4 show the mean velocity curves for the Susquehanna River at McCall's Ferry and Harrisburg, Pa., respectively. The series of measurements at McCall's Ferry extend over a period of three years, and those at Harrisburg over a period of seven years. These curves illustrate the permanency in the conditions at these two points.

In order to determine values for "n" in Kutter's formula, the slopes were measured on the west channel of Duncan's Run, Section 7, simultaneously with the current meter measurements made on July 24 and 26, 1902, and June 5, 1903. On March 8, 1904, at which date a high water gaging was made (see Engineering News, April 28, 1904), the slope between McCall's Ferry and Gage No. 2 was also measured. With these slopes and discharges, the coefficients "c" and "n" were computed in Kutter's formula, as shown in Table I.

The three measurements at Duncan's Run gave a value for the coefficient n of about .046. The conditions, however, at Duncan's Run are the most favorable in this part of the river, and many of the flood sections include brushy or wooded islands which would materially increase the coefficient.

The later determination of n at Section 10, by means of the flood measurements of March 8, 1904, gave a value of .0545. The slope used was between McCall's Ferry and Gage No. 2, the same points taken for the 1889 flood discharge, thus making the two comparable. As shown on the map, Section 10 extends across two islands, both of which are covered with underbrush and small trees, giving a section quite typical of this portion of the Susquehanna.

The computations of discharge of the 1889 flood as given in Table II, were made in 1903, using the value of n = .05, based upon the three determinations at Duncan's Run, modified by the fact, as noted above, that most of the sections included wooded islands. The determination of "n" based upon the measurements of March 8, 1904, showed this value to be approximately correct and on the safe side. The mean at the ten sections gives the discharge for the 1889 flood of 730,300 second-feet. In this connection it is of interest to note that if a coefficient of .055, as determined by the single measurement at Section 10, for the flood of March 8, had been used, the discharge would have been 685,000 second-feet, or only 2% greater than the result obtained by using the mean velocity curve described elsewhere in this issue.

METHODS OF ESTIMATING STREAM FLOW.

By John C. Hoyt,* Assoc. M. Am. Soc. C. E.

At stream measurement stations with permanent beds, the discharges for other stages or gage heights than those at which actual discharge measurements are made are usually estimated from a station rating curve. This curve is determined from points obtained by plotting the results of the various discharge measurements using discharges as abscissa and their respective gage heights as ordinates.

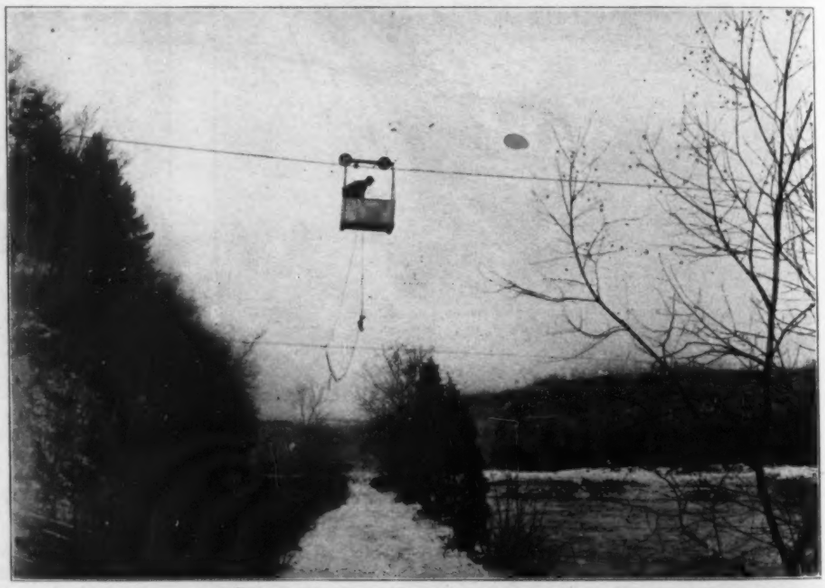


FIG. 2. CABLE GAGING STATION, SUSQUEHANNA RIVER NEAR McCALL'S FERRY, PA.

The rating curve for the Susquehanna River at McCall's Ferry, Pa.,† is shown in Fig. 1. This curve is determined by 38 measurements which, as noted in the legend, were made with Price current meters, and were taken either from a boat or from a cable (see Fig. 2). In these measurements the velocities were determined in most cases by the vertical velocity method, and the areas from cross-sections carefully measured at low water. Thus the possible error in the work

TABLE II.—Discharge of Susquehanna River During 1889 Flood, as Computed by Kutter's Formula.

No. of Section.	Area, Square feet.	Wetted Perimeter, Feet.	Hydraulic Radius, Feet.	Mean Slope.	Coefficient n.	Mean Velocity, Ft. per sec.	Discharge, Second-Feet.	Remarks.
1	89,300	4,750	18.80	.0012	.05	7.98	713,000	⅓ of section is brushy island.
2	105,500	4,210	25.06	.0006	.05	6.91	730,000	⅓ of section is low, brushy, rocky island.
3	110,400	4,300	25.66	.0006	.05	7.02	775,000	" " " " "
4	113,600	5,020	22.63	.00064	.05	6.67	758,000	⅓ of section covered with trees or brush.
5	110,500	3,220	34.32	.00035	.05	6.61	730,000	⅛ section covered with brush.
6	63,700	2,800	22.75	.0013	.05	9.43	602,000	⅓ section is covered with trees.
7	....	....	....	....	....	....	739,000	
8	89,500	2,800	31.96	.0007	.05	8.72	780,000	⅓ of section is rocky island.
9	....	....	....	....	....	....	720,000	
10	72,800	2,430	29.95	.0011	.05	10.38	756,000	⅓ of section covered with brush or trees.
Mean	....	....	....	....	....	....	730,300	

*U. S. Geological Survey, Washington, D. C.

†Data for McCall's Ferry furnished through the courtesy of Cary T. Hutchinson, M. Am. Soc. C. E.

...s reduced to a minimum. The accuracy of this ...ork is graphically shown in Fig. 1, which also ...ustrates the two principal laws of the flow of ...reams of this character, namely, that the dis...harge increases regularly with the gage height ...d that for any given gage height the discharge ...ill always be the same. Furthermore, the curve ...kes the general form of a parabola and has the

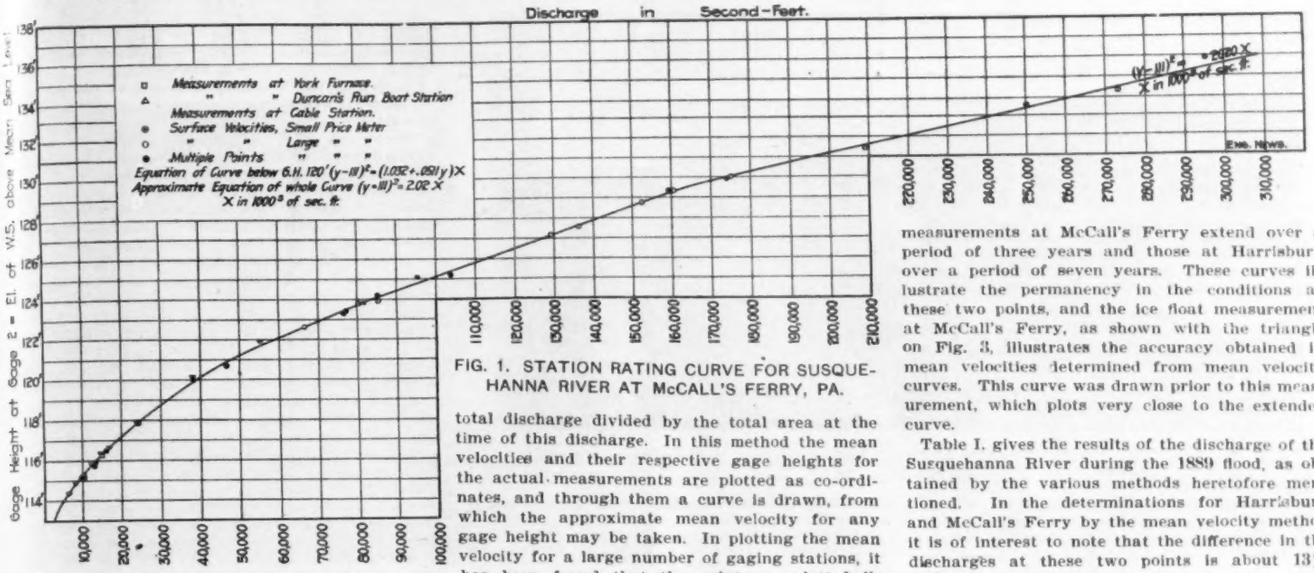

Discharge in Second-Feet.
Gage Height at Gage 2 = El. of W.S. above Mean Sea Level.
Measurements at York Furnace.
" " Duncan's Run Boat Station
Measurements at Cable Station.
Surface Velocities, Small Price Meter
" " Large " "
Multiple Points " " "
Equation of Curve below G.H. 120' (y-111)²=(1.032+.051y)X
Approximate Equation of whole Curve (y-111)²=2.02 X
X in 1000's of sec. ft.
(y-111)² = 2.020 X
X in 1000's of sec. ft.
Eng. News.

FIG. 1. STATION RATING CURVE FOR SUSQUEHANNA RIVER AT McCALL'S FERRY, PA.

approximate equation $(y - 111)^2 = 2.02x$, where y equals the gage height and x the discharge in thousands of second-feet.

The chief difficulty met with in making station rating curves is the lack of extreme high and low water measurements. As these stages occur at irregular intervals and often years apart, the measurements at such times are often missed, owing to the hydrographer not being able to reach the station before the stage has passed. The high water measurements are especially hard to make, owing to the difficulty in manipulating the meter at these stages, and the disturbance from ice and drift which usually accompany the larger floods. Owing to these conditions, it is often necessary to estimate the discharge for the extreme stages from such other data as may be at hand.

The most common method of estimating extreme high and low water discharges is by extending the station rating curve, making it follow the same general law which it has in the vicinity of the ends extended. As the discharge is the product of two factors, namely, the velocity and area, in this extension of the rating curve two unknowns are dealt with, thus introducing considerable liability to error. Furthermore, the direction of the upper end of the rating curve, which is usually practically a tangent, is quite uncertain, and owing to the large quantities usually dealt with in the maximum discharge a slight change in its direction introduces considerable error.

In the Kutter's formula method of estimating discharge, there are also many possible chances for error, owing to the unreliability of slopes and cross-sections, and the uncertainty as to the proper coefficient to use. It is the only method available, however, in cases where too few or no discharge measurements have been made.

A third method used by the hydrographers of the United States Geological Survey for estimating maximum and minimum discharges at stations where a considerable number of measurements have been made is from a mean velocity curve, the mean velocity being defined as the total discharge divided by the total area at the time of this discharge. In this method the mean velocities and their respective gage heights for the actual measurements are plotted as co-ordinates, and through them a curve is drawn, from which the approximate mean velocity for any gage height may be taken. In plotting the mean velocity for a large number of gaging stations, it has been found that the points so plotted lie along well defined curves which are usually convex upward and tend to be tangents at their upper ends. These curves can be extended beyond the limits of the measurements with a considerable degree of accuracy. From this extension the mean velocity of the stream for stages outside the limits of actual measurements can be closely approximated, thus giving one factor for the determination of the discharge at any desired stage. The area, which is the other factor, can be obtained to any degree of accuracy desired by developing the cross-section of the stream at the gaging station. By using this area and mean velocity for estimating the discharge the uncertainty in regard to one factor, the area, is eliminated, and it safe to say that this method gives results much closer than can be obtained by either extending the rating curve or using Kutter's formula. The same uncertainty exists in the mean velocity method as with the others for estimating flood discharges on streams with low overflowing banks covered with vegetation. Under these conditions, at best, only an approximate estimate of the flow can be made.

Figs. 3 and 4 show the mean velocity curves for the Susquehanna River at McCall's Ferry and Harrisburg, Pa., respectively. The series of measurements at McCall's Ferry extend over a period of three years and those at Harrisburg over a period of seven years. These curves illustrate the permanency in the conditions at these two points, and the ice float measurement at McCall's Ferry, as shown with the triangle on Fig. 3, illustrates the accuracy obtained in mean velocities determined from mean velocity curves. This curve was drawn prior to this measurement, which plots very close to the extended curve.

Table I. gives the results of the discharge of the Susquehanna River during the 1889 flood, as obtained by the various methods heretofore mentioned. In the determinations for Harrisburg and McCall's Ferry by the mean velocity method it is of interest to note that the difference in the discharges at these two points is about 13%.

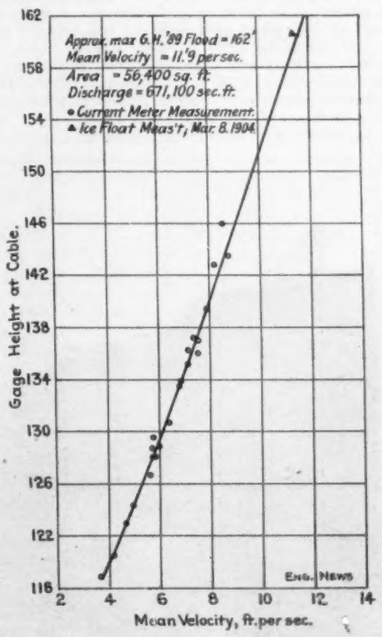

Approx. max G.H. '89 Flood = 162'
Mean Velocity = 11.9 per sec.
Area = 56,400 sq. ft.
Discharge = 671,100 sec. ft.
Current Meter Measurement.
Ice Float Meas't, Mar. 8, 1904.
Gage Height at Cable.
Mean Velocity, ft. per sec.
Eng. News

Fig. 3.

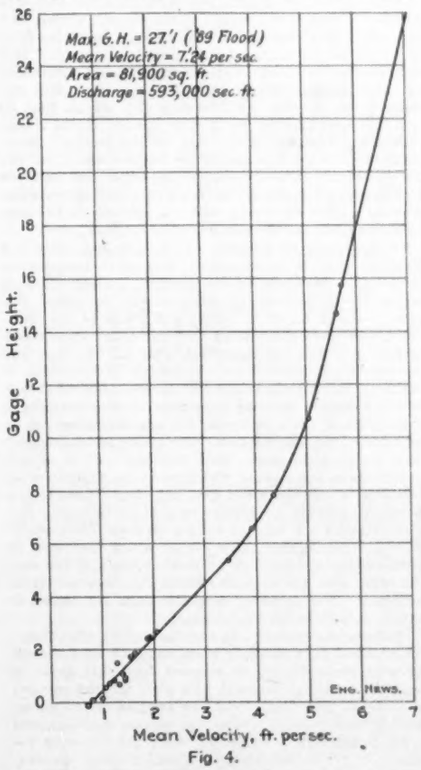

Max. G.H. = 27.1 ('89 Flood)
Mean Velocity = 7.24 per sec.
Area = 81,900 sq. ft.
Discharge = 593,000 sec. ft.
Gage Height.
Mean Velocity, ft. per sec.
Eng. News.

Fig. 4.

TABLE I.—1889 Flood Discharges of the Susquehanna River.

Station.	Gage Height Feet.	Mean Velocity Ft. per sec.	Discharge Sec.-Ft.	Method.
Harrisburg ...	27.1(a)	7.24	593,000	Mean velocity curve.
McCall's Ferry	162.0(b)	11.90	671,100	" " "
" "	145.9(c)	.....	733,800	Extending station rating curve, formula, $(y-111)^2=2.02x$
" "	162.0(b)	.....	730,300	Kutter's formula, value of n=.05.
" "	162.0(b)	.....	685,000	Kutter's formula, value of n=.055.

(a) Above low water of 1804.
(b) Above sea level at cable station, above McCall's Ferry.
(c) Above sea level at Gage No. 2, below McCall's Ferry.

which is about what would be expected, as the difference in drainage areas of these two places is approximately 11½%.

CHEMICAL SPECIFICATIONS FOR PIG-IRON.*

By B. F. Fackenthal, Jr.†

The manufacturers of merchant pig-iron can congratulate themselves that foundry-men are slowly but surely recognizing the fact that their mixtures should be made up according to chemical analyses, rather than by fracture; but in my experience many foundries ordering spec-

*From the Transactions of the American Institute of Mining Engineers.
†President Thomas Iron Co., Riegelsville, Pa.

ification-iron want the grading by fracture also. They want both the penny and the cake.

One of the largest customers of the Thomas Iron Co., who uses thousands of tons of Thomas iron yearly, always buys "No. 2 plain," stipulating for shipments from the lower pig-beds when we can furnish them. Being an old furnace manager, he knows that the iron in the lower beds, having traveled farther from the furnace, cooling as it warmed the greater length of runner, solidifies

FIG. 1. LOOKING DOWN-STREAM AT THE BREAK IN THE WATER-WORKS DAM AT SCOTTDALE, PA.

sooner in the beds, and thus presents a closer grain; whereas, the iron of the upper beds, remaining longer liquid, will exhibit after solidification a fracture of higher grade, though the two may be identical in composition. In other words, No. 2 plain iron from the lower beds may be just as good in the cupola as No. 2X of the same cast from the upper beds, while it is cheaper, when the price is determined by grade, and the grade by fracture. This founder has no laboratory; but his practical knowledge of the conditions of the pig-bed has enabled him, for many years, to save the difference of price (at least 50 cents per ton) between No. 2 plain and No. 2X on a considerable proportion of the iron he has bought. Since classifying by analysis instead of fracture would put the No. 2 plain of lower pig-beds in the same class with the higher-priced No. 2X of the same cast and composition, it is no wonder that, as a buyer of superior shrewdness, he prefers the old method.

Yet classifying by analysis, which is in such cases and in other ways often advantageous to the furnace-man, ought to be preferred by the founder, because it would enable him to calculate his mixtures with certainty. For there are both tricks of nature and tricks of the trade which may make the grading by fracture unfavorable and misleading to the consumer; and, after all, the most advantageous arrangement for both parties is that which is just to each. Unquestionably, such an arrangement should be based upon a common knowledge of the composition of the pig-iron concerned; and this knowledge requires of the founder the determination of mixtures for the cupola, based on chemical data. This, however, will be of but little value to the founder who permits his application of chemistry to stop there and does not carry it also to the floor of his foundry, by regular tests of his castings. But some founders are not yet willing to take this trouble; and, as a consequence, they cannot locate the cause of unsatisfactory castings. Often they complain of the pig-iron, when this was entirely suitable, but was spoiled in re-melting. The following examples from my record of analysis may serve as illustrations:

1. Complaint was made that a car load of No. 2X Thomas iron produced hard castings, when soft ones were desired, and were reasonably to be expected from that grade of pig. The customer returned two pigs, marked respectively "hard" and "soft," and two samples of the unsatisfactory hard castings. These four samples were analyzed in the Hokendauqua laboratory, with the following results:

	Hard pig, per ct.	Soft pig, per ct.	Casting, per ct.	Casting, per ct.
Silicon	2.680	2.633	2.327	2.257
Sulphur	0.022	0.023	0.263	0.249

The Thomas Iron Company's sampling of the entire car-load, prior to shipment, showed silicon 2.61 and sulphur 0.022%. It is unusual for the analyses of selected pigs returned to the laboratory to correspond so closely to those of the furnace sampling. The "hard" pig was doubtless chilled in the runner and, therefore, not as open-grained as the "soft" one; but they doubtless came from the same cast, and possibly from the same bed. If the founder had bought by analysis and not by fracture, he would have preferred the "hard" pig, since it was slightly higher in silicon, and slightly lower in sulphur than the "soft" one. The castings sent for analysis contained about twelve times as much sulphur as the original pig-iron, and the founder's difficulty was certainly due to bad cupola-practice. The excessive amount of sulphur in the castings may have been due partly to fuel high in sulphur, and perhaps partly to improper fluxing, but more probably to the use of too little fuel in re-melting the iron. The loss of silicon during the re-melting was about 13.8%, which shows fairly good practice in this respect.

2. Another customer, who complained that Thomas No. 2X iron gave him bad results, returned six pigs and a hard casting. The analyses of these samples, also the analysis of the pig-iron before it was shipped, are as follows:

	Furnace Sampling of Car-Load. Per Cent.	Six Pigs Returned. Per Cent.	Hard Casting. Per Cent.
Silicon	2.70	2.854	2.257
Sulphur	0.017	0.052	0.319
Phosphorus	....	0.812	0.800
Manganese	....	0.403	0.291

Loss of silicon on re-melt about 20%.

In this instance the pigs returned were much higher in sulphur, but the cause of complaint was doubtless the same as in the former instance, viz.: too much sulphur was allowed to be taken up in the cupola. A few more pounds of fuel would have corrected the difficulty and kept the sulphur out of the castings. The same customer reported that a previous shipment of iron, containing silicon, 2.40; sulphur, 0.041; and phosphorus, 0.736%, gave him entirely satisfactory results. I could give many examples of this kind, but these two are sufficient.

Many foundry-men call for high silicon iron; and if the results are not satisfactory, they seem to think that still higher silicon would correct the evil. Our experience, however, is that, in many instances, the silicon specified was already too high, and that they required iron lower, not higher, in this element.

3. A complaint was made of Thomas No. 2X iron on account of the blow-holes it contained, which, the founder said, were reproduced in his castings. The iron made at that time in one of our furnaces did, in fact, contain an unusual number of blow-holes, and we experienced great difficulty in locating the trouble, which was finally traced to the quality of the sand used for the pig-bed. The founder sent us four samples of borings, two from the pig-iron and two from the castings, which gave the following analyses:

	Pig-iron, solid part, per cent.	Pig-iron, side of blow-holes, per cent.	Castings, solid part, per cent.	Castings, side of blow-holes, per cent.
Silicon ..	2.608	2.617	1.778	1.778
Sulphur .	0.029	0.027	0.150	0.129
Phosphorus	0.856	0.860	0.864	0.852

Loss of silicon in re-melting about 32%.

I cannot see why blow-holes occasioned by bad sand in the pig-bed should be injurious to the iron, or why such blow-holes should be reproduced in the castings. Both in the pig and in the castings the sulphur was lower in the iron around the blow-holes than throughout the solid part of the pig. This is another instance in which the iron was permitted to take up excessive sulphur in the cupola, and, doubtless, goes to show that the founder was trusting to the appearance of the pig rather than to its chemical analysis.

4. Three car-loads of pig-iron shipped by rail were delivered to the wrong customers: a puddling-furnace receiving No. 2 plain, intended for a pipe-foundry; the pipe-foundry receiving a car of No. 2X intended for a pump-works; and the pump-works receiving the car of gray-forge intended for the puddling-mill. All these shipments were received and used without complaint. In these cases the fracture could not have been taken into account by the customers.

5. To a customer operating puddling-furnaces, who always specified open iron, there was shipped by mistake a car of silver-gray iron, containing 6.38% of silicon, made while blowing-in a furnace. He reported that particular carload as having given very satisfactory results; and for some time thereafter he referred to this shipment and wanted more like it. The iron was open-grained, and the appearance suited him. I have often wondered whether he used it alone or in mixture with some other iron that happened to be particularly low in silicon.

6. Some years ago, visiting a furnace-plant in the Birmingham district, Alabama, I found that special efforts were being made to keep the iron in the pig-beds hot for as long a time as possible, by covering it with sand to the depth of 6 or 8 ins. It was claimed that this annealing process toughened the iron and permitted the segregation of an additional amount of graphitic carbon. On my return home, believing that I had learned something of great value, I tried the experiment at the Durham furnace, of which I was manager at that time, with the result that after the iron was cool it was impossible to break the pigs from the sows by sledge-hammers or other ordinary means. The pig-iron was finally dragged out of the cast-house with a team of horses, one bed at a time, and the entire force of blacksmiths was used to cut it apart with cold-cutters. No further attempt to improve the fracture was made.

FIG. 2. NEARBY VIEW OF THE BREAK IN THE SCOTTDALE DAM AS SEEN FROM BELOW.

I will close these remarks by giving the following statement of interesting experiments, made in the cupola of a large foundry, to show the losses of silicon in re-melting, as affected by the presence of manganese:

Sample. No.	Manganese. Per Cent.	Per Cent. of Total Silicon Lost in Re-melting.
1.	0.04	34
2.	0.20	23
3.	0.43	12
4.	0.53	4

THE RECENT FAILURE OF A WATER-WORKS DAM AT SCOTTDALE, PA.

By Willis Whited.*

The following notes on the failure of the Greenlick dam of the Citizens' Water Co., at Scottdale, Pa., and the views of the break, are the result of a visit to the scene of the accident. The failure occurred about 10 p. m., July 17.

Fig. 1 is a general view of the dam and shows the location of the break near one end of the structure. Fig. 2 is a nearer view of the break, as seen from below. Fig. 3 was taken from the top of the main portion of the dam now standing.

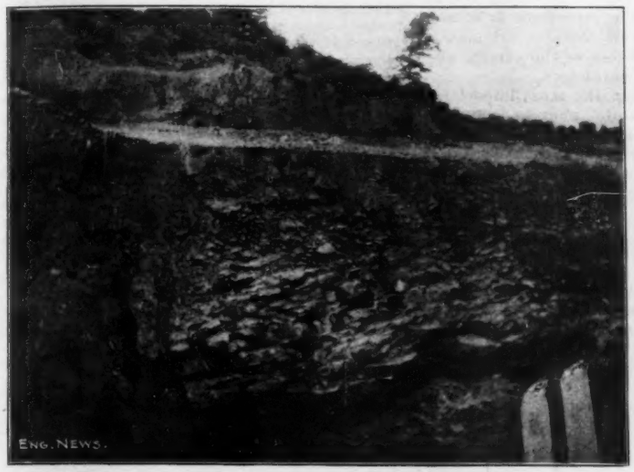


FIG. 3. LOOKING TOWARDS THE SHORE END OF THE BREAK AND SHOWING THE CHARACTER OF THE SIDE-HILL ROCK.

FIG. 4. LOOKING TOWARDS THE REMAINING PORTION OF THE MAIN DAM AND SHOWING THE CHARACTER OF THE EARTHWORK, RIPRAP AND SHEETING.

FIGS. 3 AND 4. VIEWS OF THE BREAK IN THE SCOTTDALE DAM AS SEEN FROM THE TOP OF THE DAM.

looking across the break. Fig. 4 is a view looking in the opposite direction from that shown in Fig. 4.

The dam was built three years ago. One of the contractors for the structure told me that it was built of earth rolled in 6-in. layers and that the failure started in the bank at the end of the dam and not in the dam itself. He said it was about 60 ft. high and that it would be rebuilt the same as originally. He seemed unwilling to give any further particulars.

The bank at the end where the break occurred is of bed-rock with very little soil. The rock is very seamy, somewhat shaly, and 30 to 35 ft. from its surface is a vein of coal about 1½ ft. thick. The strata have a pitch down-stream of about 5° to 8°, as shown in Fig. 3. The dam was built entirely of clayey soil, with hardly sand or gravel enough in it to prevent it flowing when saturated with water. Both faces of the dam were covered with a layer of riprap 2 to 3 ft. thick, composed mostly of one-man stone and smaller. I could find no evidence of a puddle-trench in the adjacent bank† nor of any attempt to fill the seams of the rock with mortar. Neither could I see any sign of a masonry core-wall. As shown clearly in Fig. 4, two rows of planks had been driven into the crest of the dam. The planks in each row nearly touch, and the rows are about 6 ft. apart. I will not hazard a guess as to their purpose. These rows of planks extended, apparently, the whole length of the dam; their tops were somewhat below the surface.

There are cracks across the crest of the dam every few feet for more than 200 ft. from the break. There are also other evidences of settlement, amounting to several feet, next to the break. This is shown by the irregular outline of the crest in Fig. 1. There seems to be no corresponding bulge in either face of the dam, so I suppose a considerable part of the filling became so saturated with water that it became a semi-fluid mass and when the break occurred it flowed out through the opening.

At the shore side of the break the rock is uncovered for about half the thickness of the dam. For the remainder of the thickness a considerable depth of earthwork remains, as shown in Figs. 2 and 3.

The spillway is on the bank beyond the break. It is not shown clearly in any of the views, but is a short distance to the right of the part shown in Fig. 1. The bed and sides of this are built of concrete and the overflow channel is in the natural shale rock. I neglected to get the dimensions of the spillway, but it was apparently ample. The amount of flow over it is evidently small.

The crest of the dam is of clay, about 12 ft. wide, without paving, and I could see no sign that the water had ever been within several feet of it.

The failure of the dam was not due to a flood. The leak in the embankment was discovered at 9 a. m. July 17, and at 10 p. m. the same day the washout occurred. The people in the valley below were warned to get out of the way, so no lives were lost. The valley was about an eighth of a mile wide and the water rose to a height of 6 or 8 ft. There were very few houses in the valley below and these were mostly destroyed or very badly damaged. Crossing the creek below were numerous small bridges, I suppose of wood, which were all destroyed. The water company probably suffered more damage than all others combined.

Evidently the failure was caused by water working through seams in the natural rock at the end of the dam close to the earthwork, thus starting a leak which rapidly enlarged with the usual disastrous results.

I am inclined to think the design was faulty in not providing a proper core-wall of either puddle or masonry, well bonded with the bank and the bottom, and also in not providing good heavy paving laid in cement on the up-stream face of the dam. The loose riprap with which both faces are covered is of very little use except to protect it from the erosive action of rain-water.

*286 Main St., Sta. B, Pittsburg, Pa.

†From other sources we learn that there was a puddle trench beneath the entire length of the dam, varying in depth from a few feet to 40 ft. below the natural surface. Where the washout occurred the trench was in rock, about 15 ft. wide and 30 ft. deep. Nearly all evidence of this was washed away, the escaping water carrying off nearly as much of the hillside rock as of the embankment.—Ed.

ROAD IMPROVEMENT IN BEXAR COUNTY, TEX.*

Road improvements in Texas, so far as concerted, intelligent action is concerned, is left to the several counties of the state. Only the most wealthy counties can afford to do much work on the roads, and very few have done what they could. At present, Bexar County is doing more work on its roads than any other in the state.

Bexar County is situated so far west that it is subject to alternate droughts and floods, which in turn reduce the roads to powder and wash away large portions of the roadbed. The southern and eastern parts of the county are sandy and the central and northern parts have a black and sticky soil, making a fairly good road in dry weather, but an impassable one during the rainy season.

The hilliness of most parts of the county reduces the drainage problem, in most cases, to a task of protecting the long slopes from erosion. This often necessitates the removal of the surface water through private property, or the construction of breakwaters in the ditches. Such breakwaters or dams can be easily and cheaply constructed by setting a double row of posts across the ditch, and filling the space between and below them with light bush.

For the sandy portions of the county the problem of road improvement is to find a material for the wearing surface that will resist the grinding action of the wheels in dry weather and not be washed away during heavy rains. There is no gravel near by, but at a depth of 6 ins. to 3 ft. below the natural surface there is a layer of red clay, with a slight mixture of sand. As the sand roads are good when wet, and are usually from 40 to 60 ft. wide, only a strip of the roadway was covered with clay, beginning with the deepest sand and the steepest grades. After eight years of use without repairs one such strip, on a heavy grade, shows only a few holes worn down to the sand.

In constructing these clay strips of roadway, ordinary dump wagons with a capacity of 1 cu. yd. are used. Four loads are placed side by side, crosswise of the roadway, and a fifth load on top and at the center of these. When shaped, there results a clay roadway 16 ft. wide and 16 to 12 ins. deep.

A road gang employed on this work is composed and costs as follows: 10 teams and driver, $30 a day; 8 laborers, $12; 1 foreman, $3; total per day, $45. The clay is uncovered with drag scrapers, loosened by means of plows, and loaded into wagons. One team, when the average haul is a half-mile, will haul 15 loads (or cu. yds.) a day. The plan described requires 33,000 cu. yds. of clay per mile. One gang can build a mile of roadway strip in 22 days at a cost of $990. These figures are based on actual costs. Rolling, though highly desirable, is impracticable at present, owing to the short and scattered sections of road being improved.

The most important road improvement now in progress in Bexar Co. comprises the construction of gravel roads for a distance of twelve miles in every direction from San Antonio. This work is the result of the heavy rains of 1902-3, which shut off all communication between the city and the surrounding country, so the farmers

*Based on a thesis presented for the degree of Bachelor of Science in Engineering at the Agricultural and Mechanical College of Texas, College Station, Tex., by James E. Pirie, of Parita, Tex., and A. F. Dahme, of Yorktown, Tex. We are indebted to Mr. J. C. Nagle, Professor of Engineering at the institution named for an opportunity to abstract this thesis.

could not haul in their produce. As a result, produce was brought in from distant points by rail. Public meetings were held, a Good Roads Association organized, an election called, and finally $500,000 of county road improvements bonds were issued. The money is being expended by the county court, with the advice of the executive committee of the Goods Roads Association, under the direction of engineers.

The contract for all the roads was let to one man, who agreed to complete the job in 250 working days. He is employing 500 men and 500 mules, besides many of the best modern implements for road-making. The most notable of the latter are traction engines for hauling wagon trains composed of Aurora dump wagons of 3 cu. yds. capacity each, and also a 40-HP. Vulcan steam shovel for loading the wagons. Each engine pulls six wagons at a speed of about five miles an hour over ordinary roads. The train crew is one engineer, one fireman and one laborer.

Graders are used to level the gravel after it is dumped on the roadway, and 15-ton rollers for compacting the material.

The first layer of gravel is of a flinty character, with just enough clay for binding. Most of this gravel is about 2 ins. in size, but the range is from 1 to 3 ins. The finer or second and top layer is of limestone gravel mixed with "dobe" for binding.

The 16-ft. width of gravel is 1 ft. thick at the center and 0.7 ft. at the sides, and there is an 8-ft. earth shoulder on each side. The estimated partial cost of the road per mile is $2,557, divided as follows: Earth excavation, $170; gravel, $2,314; clearing and grubbing, $32; rolling, $41. Other cost items (not available when the thesis was written.—Ed.) will be the purchase of gravel pits, additional excavation for lowering grades, etc., on account of storm water; bridges and culverts, and engineering. The preliminary estimate of the cost of the roads was $3,438 per mile.

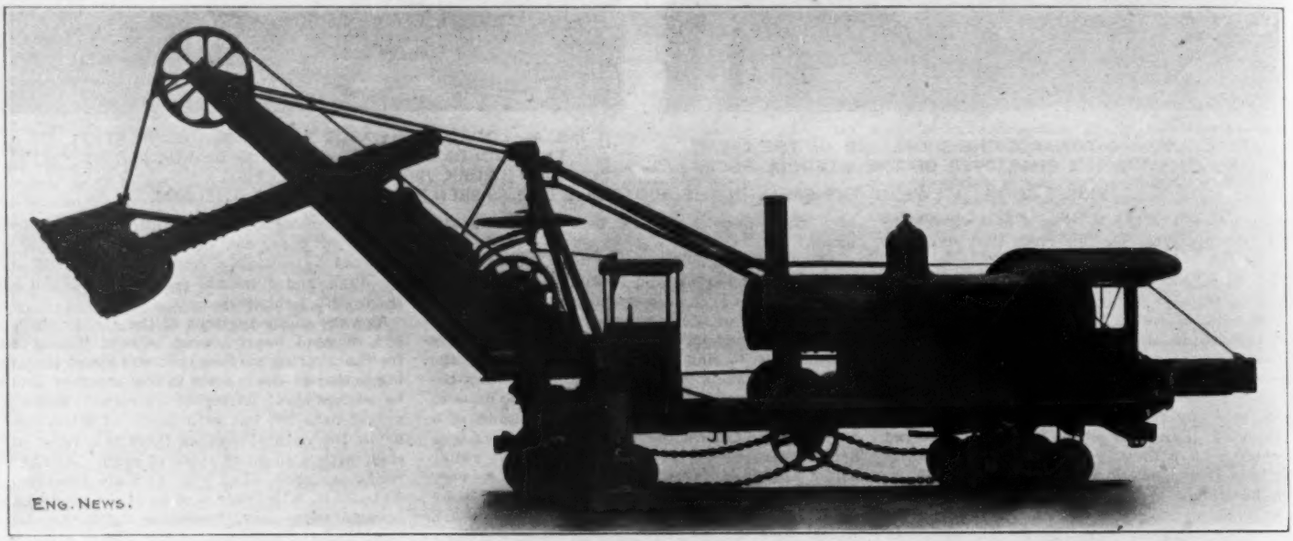
A RAILWAY STEAM SHOVEL OF NEW DESIGN.

Practice in machine design, as every engineer knows, tends strongly to follow the ruts. A change on past practice must be shown by most unimpeachable evidence to be an improvement or it will be rejected without question, and its originator will stand in danger of being marked as "an inventor instead of an engineer." For that reason, all the more credit is due to those who have the courage to break wholly with past precedents and attempt to introduce new designs on the strength of their actual merit.

The American type of steam shovel is well known to be a machine of great efficiency. As now built in the standard designs, it closely follows in nearly every detail the general lines which were adopted in the early days of steam-shovel construction. The machine herewith illustrated breaks away from this long-standard type in many particulars, and it is of much interest to study these changes and the reasons presented for adopting them.

The machine was built by the Atlantic Equipment Company, of New York City, by the American Locomotive Company, and the design was made by Mr. A. W. Robinson, M. Am. Soc. C. E. Only last week we noted the remarkable work accomplished by Mr. Robinson in the design of the great hydraulic dredge now at work on the deepening of the St. Lawrence River, which holds the world's record for capacity and efficiency. As chief engineer of the Bucyrus Co. for many years, Mr. Robinson gained a wide experience in steam shovel design, and any new features originated by him are certainly deserving of the careful attention of engineers and contractors.

As seen in the engraving, the most important changes in the new "Atlantic" shovel, as it has been named, are as follows: (1) The use of wire rope instead of chain for the dipper hoist, and hoisting by direct pull instead of by "block and tackle"; (2) placing the hoisting engines directly on the turntable at the base of the boom instead of back on the floor of the car; (3) attaching the hoist rope directly to the dipper and dispensing with the bail; (4) substituting locomotive boiler, cab and water tank construction for that usually employed. There are numerous other features, but these impress us as being of greatest importance. It will be of interest to follow in detail the reasons put forward for these innovations in design and we print the following, which has been furnished to us by the builders of the shovel:



A NEW STEAM SHOVEL FOR RAILWAY WORK.
Built for the Atlantic Equipment Co. by the American Locomotive Co. Designed by A. W. Robinson, M. Am. Soc. M. E.

The evolution of the modern American shovel has been marked by a continuous increase of strength and speed. In the earlier shovels all the motions were performed by one pair of engines, friction clutches being employed. This has now been abandoned in favor of independent engines for each motion so that they can be performed simultaneously and without interruption or delay. The usual method of hoisting the dipper is by chain, a three part tackle being employed and a hoisting engine placed on the car. This method answered sufficiently well in small sizes and for moderate speed; but for the high power and high speeds now required, a chain of 1½ ins. diameter becomes a serious matter, the chain alone weighing more than a ton and running at a speed of 500 to 1,000 ft. per minute and reversing twice per lift, or, say, 8 times per minute.

This chain runs over six sheaves and the loss of power and resulting wear is enormous. A chain makes two bends passing over each sheave, one bend going on and one bend going off. In a machine having six sheaves and lifting four dippers per minute the number of bendings for the entire length of chain will therefore be 96, or, say, 100 per minute. If 300 links in the chain pass these sheaves the number of link bendings will reach the astounding number of about 30,000 per minute.

The distinguishing feature of the "Atlantic" shovel is the direct wire-rope hoist. The friction loss in the chain hoist, to say nothing of the loss due to inertia, amounts to at least 40%, whereas the loss in the case of direct wire-rope hoist does not exceed 5 to 10%. In the Atlantic shovel there is but a single sheave used for hoisting and this of very large size.

This single sheave besides reducing friction has the very important advantage of *increasing the angle of lead* to the bucket. This is a most important feature as it determines the digging efficiency of the machine. It is of but little use to exert a heavy pull upon the dipper by means of the hoisting chains if the angle formed by those chains with the dipper handle is so acute as to produce but little effect. In this shovel this angle is increased to such an extent that the digging effect is practically doubled. In other words, the same work can be done at higher speed and greater power and with a small expenditure of steam and less strain upon the machine.

Direct wire rope hoist has been used successfully by Mr. Robinson for some years in large dipper dredges, and his work in this connection is well known.

The "Atlantic shovel" has a special advantage where high lift is required. The construction is such that about 4 to 6 ft. more height of lift can be obtained with the same length of boom as compared with other shovels, and it is possible to construct machines with a clear height of lift of 20 ft., which will work at fully as high speed as the lower lift machines of the old type. This is a valuable feature in work of re-construction of existing railroads, of which so much is being done at the present time to reduce grades.

Referring to the illustration, it will be seen that the hoisting engines are incorporated in the base of the boom so that the whole hoisting machinery revolves together. It has long been the desire of shovel builders to produce a successful wire rope shovel, but the difficulty of guiding the rope from the drum to the dipper with several large sheaves has been insuperable. In this shovel the hoisting machinery is mounted directly upon the boom so that no guide sheaves are necessary, and the power is applied in the most direct and simple manner and with the least possible loss. The hoisting engines, with drum and gearing, take up very little room and can pull the required amount on the dipper at a speed of five to six dipper loads per minute. The hoisting drum is very short and of large diameter and fits easily between the sides of the boom which constitute the frame. The gearing is of steel and amply strong to stall the engines with full head of steam. The hoisting friction is of novel type, taking up less room than usual and is quick and sensitive and does its work without heating. It is operated by steam so that the operator exerts no effort.

The A-frame is formed of solid steel bars having solid forged pin-connections at feet and a cast steel head. The A-frame is stepped upon the ends of the jack-arm truss in such a way that it forms a continuation of the jack-arms, giving great stability and relieving the car frame from strains. This type of frame is similar to that first designed by Mr. Robinson in 1892, and has since been widely imitated. The A-frame head is of new design and arranged so that the three strains intersect in a point. This is accomplished in no other shovel and obviates all lateral bending strains which frequently lead to breakage.

The A-frame can be lowered when required for transportation over the road to 15 ft. (or lower) above the rail. The pin-connections at foot of A-frame permit of this movement and the back guys are shifted forward to a

nect'on provided for the purpose. The raising and low-g of the A-frame can be done by power.

the boom there is a departure from the usual practice making it with straight taper deepest at the inner end. s form is the simplest and most direct that can be de-ed, giving the greatest strength where it is needed and least weight at the outer end where there is greatest tion. The most severe strains in a boom are those due twisting when swinging rapidly, and in irregular work used by the leverage of the dipper handle; and the boom a weak point in most shovels. It is essential that the wer flange of the boom should have its greatest strength a horizontal or lateral direction. This strength can be adily attained with light weight when the lower member straight, but it is manifestly weak if the lower member e curved. In this shovel the upper members of the boom re steel channels set vertically and the lower members re set horizontally while the web is a solid steel plate.

The turntable is built solid with the boom, being made f stiffened steel plates and a rolled rim. The turntable nd boom as a unit have perfect freedom of action, being eparate from the revolving collar on the base.

The boom in this shovel is much shorter to accomplish the same height and reach, as compared with other hove's, and is of less weight and can swing more readily with less strain into the machine. The principal weight is at the inner end on the axis of revolution, where it of-fers no resistance to rapid swinging. A shovel with a long and heavy boom creates heavy strains due to its weight and inertia, leaving little margin for effective work.

The entire frame of the engines is of cast steel, in one piece, and forms the foot of the boom and center of the turntable as well. While the weight of the engines and gearing is not great, it is located on the axis of rotation of the boom and therefore does not appreciably increase the power required for swinging nor interfere with the speed.

The base plate attached to the car is of cast steel with a revolving collar bearing of large surface so that it will run a long time without appreciable wear. The feet of the boom are stepped into sockets in this collar-bearing so that all necessary freedom is allowed.

It may be objected that the added weight of the hoisting engines on the front end is a disadvantage; in practice no difficulty is perceived. As the turntable center and boom foot, in this case, constitutes the engine frame, one casting takes the place of four or more with the usual construction and with less total weight. The load at the base of the boom due to weight of the parts is a trifle compared to the load due to working stress. So far from being a disadvantage, the location of the engines on the boom presents several important advantages, viz.:

(1) It permits direct lead of the hoisting rope without any guide sheaves and consequent wear.

(2) It leaves the car free with ample space and room for a long and efficient boiler.

(3) The weight of the hoisting machinery in the base of the boom is more effective for counterbalancing the weight of the loaded dipper in side position than if back on the car. The jack-screw being the fulcrum, this weight balances the shovel against overturning.

(4) The weight of the shovel when dismounted for transportation is more evenly distributed, the boom with its engines being loaded on a separate flat car, as usual.

The main engines are of locomotive type with outside cylinders. A sheet steel casing is provided for protection. They have solid cast steel frame for both engines in one piece and steel cross-heads, with all parts easy of access. Steam is carried by a pipe having a double ball and socket joint on top cen er, and the exhaust is carried to the smoke stack by a pipe through the bottom center.

The hoisting drum is of large diameter, grooved for steel wire rope. There are two parallel ropes each bearing half the load, equalized round a small sheave or thimble at the dipper. The two ends of the rope are secured by clips at the drum, so that there is really but one rope, and attached in such a way that the rope can be removed and replaced without delay. The cost of renewal of a steel rope 1⅛ ins. diameter, 108 ft. long, is about $40. An equivalent chain would be of 1⅜ ins. diameter and 125 ft. long, and would cost $134. The ropes will last fully as long as the chain as there is but one sheave. It will give warning of weakness due to wear before it breaks, while a chain snaps without warning. It is noiseless and far more efficient than chain and consequently will do more work with less power. It is lighter and will run faster. It can be replaced without loss of time, as the time of renewal can be chosen at a favorable opportunity. For these reasons the rope is more desirable than chain, even if it cost more. The hoisting drum is driven by two steel gears and two band friction clutches operated by steam. The clutch and throttle are controlled from the runner's stand on the car.

In the construction of the dipper Mr. Robinson has broken away from conventionality while retaining all the elements which experience has shown to be sound. He has discarded the ball and sheave and attached the double hoisting rope directly to the back of the dipper in such a way that the lines of force meet in a point situated in the plane of the resistance, or in line with the strain applied to the teeth. Several important advantages are gained by this.

(1) Bending moment on the dipper-arm is eliminated.

(2) The full mouth of the bucket is free for large boulders, etc.

(3) The dipper is stronger, lighter and has fewer parts.

(4) The dipper can be lifted to a much greater height and reach in proportion to the length of the boom.

By the old method it would require a boom 6 ft. longer to lift the dipper to the same height. This, therefore, means also a reduction in length, weight and swinging resistance of the boom, and consequently a better and speedier shovel.

The entire back of the dipper is in one piece of cast steel with lugs formed upon it to receive the dipper-arm, hinges for doors, etc. The lip and teeth of the dipper are exceptionally strong and attached so as to be easily renewable.

Independent thrusting engines are employed to feed the dipper to its work. By their use the cranesman has absolute control of the dipper and can cause it to fill every time while in a proper bank. These engines are solidly built with bedplate in one piece and well bolted to the boom. The gearing is of steel and the engines are reversing by means of central valve.

These engines are of new design and are entirely enclosed with no rocker arms, valve-spindles, etc., exposed as in other designs. There is nothing about these engines that can be easily injured by flying fragments from blasting, etc.

Independent reversible engines are employed for swinging a duplicate of those on the boom for thrusting, and double-geared to a drum. The drum carries double steel wire ropes on each side, which are connected to the turntable.

The propelling motion is performed by the swinging engines, power being transmitted to a cross shaft underneath the car. This shaft is connected with the forward and rear axles by two chains of great strength, sufficient to slip the wheels.

The swinging and propelling shafts are all short and strong, being attached to the main central beams of the car, which are close together.

In the ordinary type of shovel the car is crowded with the main engines and other machinery, and the boiler is squeezed into the space that is left. In this shovel there is room for a first-class locomotive boiler, and the greatest care is bestowed upon its design and workmanship. It is large enough for a locomotive of twice the cylinder capacity, and is, therefore, easy steaming. It is built for a working pressure of 140 lbs., which more nearly accords with locomotive practice than has been usual on steam shovels, and which conduces to economy as well as speed and power.

In the matter of housing-in the car Mr. Robinson has again been unconventional. The ordinary shovel is covered in like a wooden box car, which looks well when new, but does not stand the test of service and is not fireproof. In this shovel everything is covered that needs to be covered and the rest is left off and no woodwork whatever is employed.

The boiler is logged with magnesia blocks and heavy sheet steel, painted. The working parts of the swinging engines on the car are covered in with steel plate. All gearing is covered by a protecting plate over the teeth, which keeps flying rocks from blasting from getting into them, and is also a protection for the operator. All the remainder of the machinery is weatherproof, as much or more so as a locomotive. A commodious steel cab is provided for the fireman, containing feed pump and injector, with lockers for tools, and another for the engineer or runner, and also a shelter for the cranesman.

These novelties give the shovel a somewhat odd appearance to those accustomed to the usual housed-in shovel, but it is believed that in all vital and essential parts nothing is lacking to make a perfect machine and one which is on a distinctly high plane as regards engineering design and quality of workmanship. For situations in which it is necessary to enclose the entire machine, however, it, of course, can be done.

VIEW OF FRONT OF WALL.

VIEW OF BACK OF WALL.

A BUTTRESSED CONCRETE RETAINING WALL AT ITHACA, N. Y.

Henry N. Ogden, Assoc. M. Am. Soc. C. E., Chief Engineer.

The shovel is mounted on two all-steel trucks of diamond pattern specially designed for the purpose and having a large excess of strength over the requirements. The rear truck is fitted with hand brakes.

Coal and water supply is amply provided for by water tanks of large capacity and a coal platform attached to and projecting from the rear of the shovel. This coal platform is built entirely of steel and is hinged in such a way that it folds up against the rear of the machine when not in use.

The shovel illustrated is one in use by the New York Central & Hudson River R. R. It is designated by the builders as a Class 38-16-2½ machine. This means a shovel having a pull upon the dipper of 38,000 lbs., a clear height of lift of 16 ft., and a dipper holding 2½ cu. yds.

Another shovel of this design is in the exhibit of the American Locomotive Co. at St. Louis, and a third is at work on the excavation for the Pennsylvania R. R. terminal in New York City.

A CONCRETE RETAINING WALL WITH BUTTRESSES.

In probably 90% of the cases where concrete has been substituted for stone masonry, no change has been made other than the change in the material. Now the greatest advantage of concrete construction is not that it is cheaper, cubic yard for cubic yard, than stone masonry. This may or may not be the case. The great advantage of concrete is that it can be molded

into forms which are better adapted to the purpose in hand than the simple forms practicable with stone masonry.

Retaining wall construction is an excellent example. A stone retaining wall must have a solid cross-section, and if buttresses are used, as they are occasionally, they are very small, and the bulk of the material is placed in the wall itself. With concrete, on the other hand, it is perfectly practicable to greatly extend the buttresses, and thus the base, which resists overturning, and at the same time reduce very greatly the material in the wall itself. We illustrate herewith a concrete retaining wall of this type recently built at Ithaca, N. Y., by Mr. Henry N. Ogden, Assoc. M. Am. Soc. C. E., who writes concerning it as follows:

The photograph and description of the concrete abutment, described in your issue of July 21 as built at Monticello, Ill., suggests the accompanying photographs may also be of interest. The wall shown serves to support, for a distance of 150 ft., the lower side of a roadway built along a side hill and has an average height of 15 ft. The wall was not built with a gravity section, bu the overturning and sliding tendencies were resisted by the heavy, stepped abutments, plainly shown on both photographs, and the wall acted entirely as a beam between these piers. The earth pressure was estimated by the usual methods and these buttresses were proportioned graphically to carry that pressure. The concrete slabs, reinforced with expanded metal, had a span of 14 ft. and are presumably safe without counting on any tensile strength in the concrete. In order to meet, at least partly, the conditions of unequal loading in the lower part of the slab, the expanded metal was put in double for the bottom 6 ft. of the wall. The thickness of the slab was 15 ins. at the bottom and 9 ins. at the top of the wall. It was estimated that, as compared with ordinary methods, about 50% of the concrete was saved by this method of construction, which is, of course, possible only where the projection of the buttresses on the lower side of the wall is not objectionable.

THE BURNING OF THE "GENERAL SLOCUM" in the East River at New York on June 15 has resulted in seven indictments by a Federal grand jury which investigated the disaster. Three persons were indicted for manslaughter: Capt. William Van Schaick, the captain of the "General Slocum"; J. J. Fleming, U. S. steamboat inspector, and Henry Lundberg, U. S. steamboat inspector on probation. Four other persons were indicted on the charge of aiding and abetting the captain of the vessel in neglect of duty; they are: Frank A. Barnaby, J. K. Atkinson and F. B. Dexter, respectively president, secretary and treasurer of the Knickerbocker Steamboat Co., owner of the "General Slocum"; and Captain Pease, commodore of the fleet of the Knickerbocker Steamboat Co.

FIRES CAUSED BY ELECTRICITY are reported upon by the Electrical Bureau of the National Board of Fire Underwriters under date of July 11, 1904. The record covers the three months since April 11 and includes 145 fires with losses aggregating over $172,000. The 33 fires specially mentioned in the report were due to various causes, but chiefly to grounding, short circuiting, destroyed insulation and defective wiring. In addition to the above the following summary is noted:

Twenty crosses of telephone, telegraph and other signalling circuits, with lighting and power circuits have been reported. Twelve fires have been caused by dynamos and motors, in eight cases due to burning out of armature or field coils. Twenty-seven cases of the grounding of circuits are reported, of which twelve were on awnings and metal work of buildings. Five fires have been caused by short-circuit in flexible cord, due principally to the use of defective "commercial" cord with thin rubber insulation, and to the wrapping of the cord around pipes, nails, etc., which injure the insulation. Six fires are reported due to short-circuit of wires in fixtures. Four fires were occasioned by short circuit in wattmeters, one of the devices being an old style chemical meter. Four fires were due to the use of open link fuses, principally in the defective porcelain cutout blocks. Five fires were caused by the heat from incandescent lamps located near inflammable material. Twelve reports of damage by lightning have been received. In at least four of these fires the lightning entered the building over the lighting or signal wires, which were not protected with reliable protective devices. Six fires have occurred in electric cars. Twelve pole and tree fires are reported.

RAILROAD ACCIDENTS IN THE FIRST QUARTER OF 1904.

The quarterly bulletin of railway accidents issued by the Interstate Commerce Commission shows a decrease in total casualties from the preceding three months and from the corresponding quarter of 1903. Particularly in the item of falling from cars have casualties decreased, the number of employees killed from this cause being 32% less than in the last quarter of 1903.

We reproduce herewith tables giving the summary of total accidents, the summary of collisions and derailments, and a statement of the causes of 26 prominent train accidents which occurred during the quarter. It is noteworthy that of the 20 collisions whose causes are given in the last table, 13 were due to some error in connection with the movement of trains by telegraphic orders and hand signals. It is merely a new illustration of the inherent defects in this system of railway operation.

A remarkable cause of accident is recorded under the head of derailments, viz., the failure of brakes due to the freezing of the packing leather in the cylinders, allowing the air to leak out so that the train ran away on a 1½% grade.

TABLE I.—Summary of Casualties to Persons—January, February and March, 1904.

	Passengers.		Trainmen.		Trainmen in yards.		Yard trainmen (switching crews).		Other employees.		Total employees.	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
Collisions	6	651	57	564	15	250	15	89	12	104	99	1,006
Derailments	7	313	62	734	7	69	4	69	1	69	74	891
Miscellaneous train accidents (excluding the above), including locomotive boiler explosions		21	14	269	6	72	4	69	3	15	27	425
Total train accidents	13	985	114	1,566	28	391	23	169	16	179	181	1,822
Coupling or uncoupling			15	214	15	239	26	414	1	19	70	857
While doing other work about trains or while attending switches			16	1,269	15	693	14	501	22	469	65	2,932
Coming in contact with overhead bridges, structures outside of track, etc.		2	22	146	2	83	9	72	3	16	37	317
Falling from cars or engines or while getting on or off	25	395	57	998	39	639	47	642	19	223	111	2,433
Other causes	11	296	33	158	27	157	27	158	240	2,326	311	2,896
Total (other than train accidents)	30	693	143	2,785	91	1,691	123	1,786	285	2,803	689	9,055
Total all classes	79	1,680	256	3,750	119	2,072	146	1,974	309	3,046	840	10,954

Note.—Accidents to employees resulting in slight injuries which do not prevent the employee injured from performing his accustomed service for more than three days, in the aggregate, during the ten days immediately following the accident are not reported.

TABLE II.—Collisions and Derailments.

	Number.	Loss.	Persons Killed.	Persons Injured.
Collisions, rear	535	$564,686	6	651
Collisions, butting	357	306,213	66	564
Collisions, trains separating	298	182,599	6	89
Collisions, miscellaneous	670	304,566	3	30
Total	1,859	1,352,813	132	1,334
Derailments due to defects of roadway, etc.	226	172,909	11	313
Derailments due to defects of equipment	289	411,525	10	69
Derailments due to negligence of trainmen, signalmen, etc.	74	80,433	9	69
Derailments due to unforseen obstruction, etc.	76	82,140	15	72
Derailments due to malicious obstruction of track, etc.	3	11,964		21
Derailments due to miscellaneous causes	323	134,604	17	313
Total	1,149	893,584	62	891
Total collisions and derailments	2,779	2,246,477	194	2,225

Note.—Collisions and derailments which cause no death or personal injury and which cause over $150 damage to the property of the railroad are not reported.

Several other serious accidents were at least partially attributable to extreme severity of weather.

A class of accidents worth special attention is that in which conductors and enginemen fail to identify correctly the trains which they are to pass at a meeting point. An example is No. 17, where a north-bound passenger train was ordered to wait at a meeting point for four south-bound freight trains, and waited for only three. That a railway with a traffic so heavy as to require it to run freight trains in four sections ought to have a complete block signal system will hardly be questioned. Apparently, something in the shape of fixed signals was in use, since it is stated that the operator was also at fault for clearing the signal; but had the electric train staff been in use, protection would have been afforded against such a failure of human vigilance.

Causes of 26 Prominent Train Accidents, Jan. 1 to April 1, 1904.

No.	Class.	Kind of train.	Killed.	Injured.	Damage to engines, cars and roadway.	Cause.
		COLLISIONS.				
1	B	F. and F.	0	3	$2,300	Dispatcher (experienced, and with good record) overlooked orders; his age 32 years.
2	B	F. and F.	1	0	2,400	Engineman (who was killed) fell asleep 3 or 4 minutes before reaching meeting point.
3	B	F. and F.	0	16	3,160	Sixteen employees, who were injured, were riding in caboose, which was the leading car of a work train moving westward; engineman of eastbound passenger train misread name of station in order.
4	B	P. and F.	0	6	3,600	Wrong signal given; back wire of signal had been frozen and was disconnected; front wire probably pinned down by a piece of iron dropped from a train.
5	B	F. and F.	0	4	3,900	Butting collision of extra freight trains; dispatcher failed to make meeting point; his experience 13 months as dispatcher, 12 years as operator.
6	B	P. and P.	0	14	4,941	Conductor neglected to deliver meeting order to engine man.
7	B	F. and F.	0	3	5,000	Operator, 8 months' experience, failed to deliver order.
8	B	F. and F.	1	0	5,900	Flagman, who had been ordered to hold one of the trains, went into caboose to get red light; sat down to warm himself and dry his clothes; fell asleep; had been on duty 16½ hours.
9	B	P. and F.	1	2	7,298	Engineman and fireman of empty engine misread telegraphic order; engineman in handing order to fireman told him what it read, but did not tell him correctly; order read "2d No. 1"; these men read it No. 1.
10	B	F. and F.	1	8	7,400	Operator failed to notify southbound train that a northbound train, first section, had brought to that point signals for a second section.
11	B	F. and F.	2	1	8,730	Operator signed conductor's name to order, but then failed to deliver it; expected conductor to come into office for clearance card, but conductor neglected this duty; both experienced men.
12	R	P. and P.	0	11	10,242	Collision within yard limits; foggy; failure to flag.
13	R	F. and F.	0	4	10,400	Air brakes frozen and would not work; conductor and brakeman in caboose did not hear whistle signal for hand brakes.
14	B	P. and P.	2	8	12,526	Misplaced switch (10 p. m.); brakeman, for some unaccountable reason, turned switch in face of train.
15	M	P. and F.	3	3	14,500	Passenger train ran past station; in setting back, ran over a switch, which had meantime been turned, and crushed caboose of freight train on side track; 3 passengers in caboose killed; freight brakeman, in charge of switch, 22 years old; on duty 14 hours 58 minutes.
16	B	P. and F.	5	8	17,100	Engineman on northbound train neglected to examine register, and so was ignorant of non-arrival of southbound train; proceeded and collided with it at 30 miles an hour. Engineman depended on conductor to check southbound train, but conductor failed to check correctly.
17	B	P. and F.	0	9	19,000	Northbound passenger ordered to wait for 4 southbound freights; waited only for 3; operator also at fault for clearing signal.
18	B	P. and F.	18	87	26,500	Occurred at 1 a. m.; passenger train passed a meeting station without stopping; conductor and engineman did not correctly identify freight met at station.
19	M	P.	0	11	27,180	Passenger train entered siding at night at high speed; misplaced switch; some evidence that it had been maliciously misplaced.
20	R	P. and P.	4	9	29,400	Foremost train standing at water tank; second train following too closely; furious snowstorm and wind, and very low temperature.
		DERAILMENTS.				
1	D	P.	0	7	$10,000	Unknown.
2	D	F.	0	0	10,400	Broken wheel.
3	D	F.	0	0	11,500	On 1¼ per cent. grade; air brakes failed; extremely cold weather; packing leather in air-brake cylinders frozen, allowing air to leak out; engineman, 3½ years' experience, failed to call for hand brakes in season.
4	D	F.	0	0	11,901	Broken flange; wheel cast-iron, 33 ins., 600 lbs., made in 1893; chill was too deep and wheel was not bored true.
5	D	P.	0	0	14,121	Track distorted by solar heat.
6	D	P.	0	0	23,200	Misplaced switch; wreck burned by fire starting in oil which ran out of the tender.
		Total collisions and derailments	38	164	292,959	

Note.—R. Stands for rear collision; B., butting collision; M., miscellaneous collisions; D., derailment; P., passenger train; F., freight and miscellaneous trains.

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ADVERTISING RATES will be furnished upon application. "Want" and "For Sale" notices (special rates), see pages 26-27. The pages for new "Want" "Proposal" and "For Sale" advertisements are held open until Wednesday noon.

A very remarkable situation has developed on the Grand Trunk Pacific Ry. in Canada, with reference to the employment of engineers from the United States on the surveys. Canada has an Alien Labor law, under the terms of which, it is claimed, that the employment of engineers from the United States is illegal. After an agitation which has been going on for some months, a Government Commission was appointed to make an investigation into the charges of discrimination against Canadian engineers. As a result of this investigation something like a wholesale deportation of engineers from the United States is reported to be now in progress.

Without doubt, every engineer who takes pride in his profession, no matter where he may reside, will view with great regret this attempt to divide the profession on political boundary lines. Of all the professions, engineering is the most thoroughly cosmopolitan. It knows no international boundaries. The work of English engineers and French engineers and German engineers is found in every quarter of the globe. In the United States only a small percentage of the engineering work has been carried on by engineers born and trained in this country. Engineers from England and Germany and France and from Canada herself have co-operated in this country in every field of engineering work. Moreover, these men from foreign countries have not been employed in subordinate positions merely. They are numbered among the acknowledged and honored leaders of the profession.

This international interchange in the engineering profession has been in the highest degree advantageous. It was the American engineers in the Transvaal who introduced modern methods of gold extraction. English engineers have brought their knowledge and experience in ship and marine engine building to the United States to our great profit. In municipal engineering, again, the New World is indebted to the engineers of the Old for many notable advances in practice, while in the field of machine tools all the world has been glad to learn in recent years from the United States. Many more illustrations might be given; but it is surely clear that the country which deliberately shuts out engineering talent from outside its borders is running a risk of serious loss. Apply the same principle to all other callings, and the result is the policy which has kept China stationary for thousands of years, while all the rest of the world has moved forward.

It is claimed, however, that Canadian engineers have been unfairly discriminated against, and that the managers of the Grand Trunk Pacific Ry. have made a regular practice of giving employment to applicants from the United States, and rejecting applications from Canadian engineers equally well qualified. If this were really so, undoubtedly Canadian engineers would have a just grievance; but it seems exceedingly difficult to believe this to have been the case. What motive could the Grand Trunk Pacific Ry. managers have for such a discrimination? So far as there has been selection of United States engineers, it has probably proceeded from the fact that the officers at the head of the work were from the United States. Naturally, they would select for responsible positions men with whose experience and qualifications they were personally familiar, and these men would usually be also from the United States. They, in turn, would naturally adopt the same course in the selection of their subordinates. In all this there is no real discrimination and no ground for international ill feeling. It is just what would naturally take place were a Canadian engineer placed in charge of an important work on this side of the border.

We are confident that the best and most representative element of the engineering profession in Canada is opposed to the erection of national boundaries in the profession. As an example, we may quote the following extract from a letter published in the Ottawa "Free Press" by Mr. M. Murphy, of Halifax, N. S., who is a Past-President of the Canadian Society of Civil Engineers:

> This investigation is, to me, as it must be to others, an annoying proposition, for, although we cannot suffer our rights to be ignored, we should not object to the employment of American engineers by denying recognition to those who may fill their places efficiently and justly. We want interchanges of knowledge in the profession; we want to teach and be taught. There is, every day, in the progress of time, something to learn, and the more we know the more our experience teaches how much there is to learn. English-speaking engineers, some of them still living, built and equipped the first lines of railway, the world over; there were no circumscribed bounds. The present generation may do better, but there is much to learn, and interchange of thought and experience are always desirable to keep abreast with the time.
>
> Although the investigation now pending may contribute adequate protection, civil engineers ought to entertain greater ideals than those afforded by an Alien Labor Act. The Act may be necessary so far as its scope extends, but that it should embrace the work of the civil engineer, whose professional limits cannot be localized, gives some ground for reflection.

In commenting upon this, the Halifax (Nova Scotia) "Chronicle" says:

> Canadians should take care not to go too far lest they injure themselves. We must not forget that many Canadian engineers have found, and are finding highly advantageous employment in the United States; and that to insist upon the rigid exclusion of American engineers from Canada would be to provoke reprisals from which we should necessarily suffer considerably.
>
> "Know-Nothingism" is a poor business in any country. As a British country Canada should be far above it. Fair play we should have; but we should be content therewith.

To add point to the comment just quoted, we may instance the professional career of Mr. A. W. Robinson, to whose ability as a dredge designer we paid a well-deserved compliment in our last issue. As we then stated, when one of the largest American companies making excavating machinery some years ago wanted a chief engineer they sent to Canada for Mr. Robinson. After a long period in this position, Mr. Robinson returned to Canada; but that he still continues to do work for clients on this side of the border is shown by the notable steam shovel designed by him for the Atlantic Equipment Co., of New York City, and illustrated in our present issue.

This is only one name by way of illustration. A long list of Canadian engineers have come to the United States and found profitable employment, and, on the other hand, men like W. C. Van Horne and Charles M. Hays have gone from the United States to Canada, and have by their ability wrought great benefit to the country. It is to the interest of both countries that such free interchange should continue.

The so-called "squat" of vessels when under way is a matter on which great diversity of opinion and very little real knowledge has existed hitherto. We have the pleasure, in this issue of Engineering News, however, of presenting to our readers a report of the only careful investigation ever made, so far as we are aware, to determine the amount of additional submersion of vessels due to their motion through the water.

The practical importance of this investigation is apparent at a glance. If a vessel under way in a shallow channel draws 2 ft. to 4 ft. more than when at her pier, the fact is one which should be known by steamship men and by engineers in charge of harbor improvement everywhere.

Ocean steamships of large size have at the present day such great draft that in nearly every port of the world their cargo capacity is fixed by the depth of the channel. That depth is measured, of course, from the surface of the water, and the draft of the vessel is taken as she lies at her pier. If, now, a vessel draws 2 ft. more when underway, the practical effect is the same as if the channel were 2 ft. shallower.

Turning now to the results obtained by Mr. Babcock, it may be said at once that they are so astounding that many engineers, we presume, will be disinclined to accept them without careful study and verification by further experiments. That a vessel should settle at the stern and lift at the bow when running at speed is not surprising; but that both bow and stern, or, in fact, the whole hull, should when in motion sink lower in the water by from 1 to 3 ft. than when at rest at the pier, seems well-nigh inexplicable. If the observations showed a lifting of the vessel, that could be explained by the piling up of the water about the forward part of the ship; but for the whole hull to settle 2 or 3 ft. lower in the water means, in case of a large ship, a depression equivalent to that which would be caused by an added load of some thousands of tons.

We trust Mr. Babcock's experiments may be repeated by other observers in some of the other great ports of the world. If a vessel can scrape the bottom in water of 4 ft. greater depth than her draft in still water, the fact is one of which every engineer engaged in river and harbor work will wish to be informed.

In our issue of June 16 we reviewed the recent English investigations into the effect of stone dust in causing miners' phthisis, and urged that similar investigations should be undertaken by the Department of Labor to determine whether workmen exposed to stone dust in this country are suffering from similar diseases. As we then pointed out, there appears to be a wide difference in the physiological effect not only of different sorts of dust, but of dust from different sorts of stone. Dust from hard, flinty rocks appears to be far more injurious than from soft rocks.

Since that article was published, it has come to our knowledge that in one locality in the United States where a very hard sandstone is quarried and extensively used, there is a prevalent opinion among the stone-cutters that any man who works from his youth on this stone is likely to die of consumption before reaching the age of fifty. The people who hold this opinion also believe that workers of granite or limestone do not suffer in the same way. This idea is firmly established not only in the localities where the sandstone is quarried, but in adjacent cities, where it has been extensively used as a building material for over thirty years.

It seems altogether probable that there must be an actual basis of fact beneath this widespread popular belief; but to determine the facts beyond the possibility of doubt would require an investigation of a breadth and scope that only the Government could make. Requests for such an investigation from organizations of mining engineers or mine employees would doubtless be of value in enabling the Department of Labor to obtain funds and authority to undertake the work.

Perhaps one reason for the general neglect of underground waters for public water supplies is the uncertainty as to whether there are such waters available. Few engineers are competent geologists and to obtain reliable advice as to the prospects of obtaining water before going to the expense of making an artesian boring is not al-

ways an easy matter. There have been cases, we believe, where towns or small cities have engaged the services of local "water-witches" to advise them where to dig for an underground water supply; but while private individuals may still occasionally employ some party of local reputation to search for water with a hazel wand, we do not hear, nowadays, of such methods being adopted where large wells for public water supply are concerned.

We note with interest, therefore, that an investigation of the underground waters available for the supply of the city of Waterloo, Ia., has just been made by the U. S. Geological Survey. As our readers will remember, Waterloo was scourged by a typhoid epidemic last winter as a result of the defective operation of a mechanical filter; and the advice of engineers retained to report upon the situation was to adopt slow sand filtration or obtain an underground water supply.

The geologist making the report was Prof. W. H. Norton, of Cornell College, Iowa, and he advises that the probabilities of obtaining an artesian supply are good. The rocks underlying the vicinity consist of alternating beds of porous limestone, sandstone and shale, sheathed in several instances with impervious shales and several of these strata receive waters from higher ground in the region north and east of Iowa. He advises that experimental borings be carried to a depth of at least 2,500 ft. To yield the desired quantity of 3,000,000 gallons per day will probably require ten or more wells, and whether that amount is obtainable can, of course, be determined only by trial.

And now, after writing down our opinion above that in this age of enlightenment the "water witch" and the hazel divining rod had disappeared, we found in the "American Machinist" of July 21 a contribution entitled "A Water Diviner and His Work," which shows that faith in the hazel wand and those expert in its use survives in England if not in this country.

According to this paper, three bored wells have recently been driven at the works of Meldrum Brothers, Engineers, near Manchester, the sites for the wells being located by a professional "water diviner," named Henry Chesterman, who was also, it appears, a contractor for wells, and who had sufficient confidence in the reliability of his "divination" to take the well-boring contract on the terms of "no water, no pay." According to the writer of the paper, this expert located two spots where he declared water would be found at a depth of 45 to 50 ft., to the amount of at least 250 gallons per hour. Water was actually struck at 45 and 48 ft. in the two wells, which have since furnished a supply at the rate of 360 gallons per hour each! The writer then continues:

> But perhaps the most remarkable of Mr. Chesterman's undertakings with which we have to deal was in connection with the boring of the third well within the last few weeks. In March last he tested the ground again and estimated the depth of the underground water course at about 95 ft., and guaranteed a capacity of 600 gallons per hour, although he said he expected this to reach 1,200 gallons per hour. Boring was commenced in the middle of April and after cutting through 7 ft. running sand, 2 ft. clay, 25 ft. red sandstone, 18 ins. red clay and green sand, 5½ ft. gray sandstone, 16 ft. red sandstone, 18 ins. red clay and green sand, 20 ft. red sandstone, 18 ins. gray sandstone, 14 ft. red sandstone, and a further 18 ins. of clay, the stream sought was tapped at 94½ ft. down, on May 6. The 6-in. steel artesian tubing was shortly after driven into the bore-hole and the well was tested with a rotary hand pump. Exactly 1,200 gallons per hour were drawn without lowering the normal pumping level of the water in the tube.
>
> Tests were later made of Mr. Chesterman's alleged peculiar powers, and are alleged to have shown that the "wand" would turn when grasped by him even when its ends were held fast by pincers. It is also stated that instead of the traditional forked twig of hazel wood, Mr Chesterman now uses an aluminum wire bent into similar form, and obtains equally satisfactory results. He is said to ascribe the phenomenon of the twig's turning to the influence of electric currents upon the nervous system of the "diviner."

We might comment on the above from several points of view, but will confine ourselves to the interesting contrast between the investigation of underground waters at Waterloo, Iowa, and at Manchester, England.

STATEMENTS OF CEMENT MANUFACTURERS AS TO THE INCREASED COST OF FINE GRINDING.

Some time ago a specification for Portland cement was sent to a member of our editorial staff for criticism. There was one feature of the specification that was more exacting than is customary, namely, a clause that required 75% of the cement to pass a 200-mesh sieve. The prevailing practice among American engineers in recent years has been to specify not less than 90 to 95% through a 100-mesh sieve, and in many cases the specifications have called for 70% through a 200-mesh sieve. It seemed, therefore, that to call for a cement with a fineness of 75% through a 200-mesh sieve, was of doubtful economic advantage. In answer to this criticism, the author of the specifications replied that the additional cost of the finer grinding was merely nominal, probably not more than 3 cts. per barrel; but, as no statistics were offered to substantiate this claim, it seemed to us that an effort to secure data direct from cement manufacturers might not be without good results. With this end in view a number of letters were addressed to the largest and best known Portland cement manufacturers in the United States. We think that the answers received from the manufacturers will come as a surprise to many engineers who held the belief that a slightly increased fineness adds little to the cost of cement manufacture; and for that reason we give abstracts from all the letters that contained any definite data on this subject. At the request of several manufacturers the names of the writers are withheld from publication. The following are the ten letters bearing upon the subject of fine grinding:

Letter No. 1.—It is our opinion that the capacity of a tube mill is reduced about one-third in grinding so that 75% will pass through 200-mesh screens, as compared with 70% passing through the same size.

Letter No. 2.—Our superintendent estimates that the output of the plant would be reduced 20% to 25% to grind cement 75% fine through a No. 200 sieve, as compared with results operating the mill to obtain finished product, 70% of which would pass through a No. 200 sieve.

Letter No. 3.—Replying to your favor, we would state that experience has shown us the difference to grind cement so that 75% will pass a 200-mesh screen instead of 70%, as has been called for in some specifications, requires practically 10% more grinding machinery, and 10% more horse-power. For your further information I would say that if 80% were asked for to pass the 200 mesh, in specifications, it means about 25% more grinding machinery, and also 25% more horse-power. In other words, this 5% difference in fineness reduces the grinding capacity of a 2,000-barrel plant down to 1,800 barrels per day.

Letter No. 4.—Replying to your letter, would say that we have never made comparisons as to time between grinding to 75 from 70% on a 200-mesh sieve. We cannot state exactly what extra time it would take for this additional fineness. We had one experience about a year ago of an engineer calling for extreme fineness which made it necessary to run one of our mills on fine cement only. The normal fineness is 92% on a 100-mesh sieve, while the fineness required by the engineer on the work in question was 97%. This approximates on a 200-mesh sieve 72 and 80. The output of our mill fell off 40%; in other words, it took us almost twice as long to grind to 97% as it took to grind 92%. Of course, it must also be taken into consideration that our entire mill was equipped to grind at 92%. We are satisfied though that the grinding expense would be from 20 to 30% additional for this extra fineness.

Letter No. 5.—So much depends upon the character of clinker, type of grinding machinery employed, aging and other special conditions that it is almost impossible to give any exact figures as to the relative cost of reducing cement to 70% through the 200 screen, as compared with reducing to 75% passing. I believe that as a general proposition, conditions being equal, the increased fineness would reduce the capacity of a plant at least 10%, but can give you no exact data bearing upon this point. I do not think the change from 70 to 75% would begin to have the same effect in reducing output as the change from 75 to 80%.

Letter No. 6.—It is a fact that the finer the cement is ground the more the output decreases. Some years ago we made comparative tests at our German plant and found that we could grind clinker out of the Dietsch Kilns screened for about six weeks at the following rate:

1,500 to 1,600 barrels with 4 to 5% on the No. 900 German standard sieve.

5 Ball Mills No. 5 Krupp, screen 64 mesh on the square centimeter.

3 Smith Mills 1,200 mm. diameter.

1,300 barrels with 3% on the No. 900 German standard sieve.

3 Ball Mills No. 5 screen 64 mesh on the Q. C. M.

2 Ball Mills No. 5 screen 80 mesh on the Q. C. M.

1,100 barrels with 6.5% on the No. 900 German standard sieve.

3 Ball Mills No. 100 mesh on the Q. C. M.

2 Ball Mills No. 120 mesh on the Q. C. M.

We do not consider it profitable to grind much finer than 70% through an American 200-mesh screen.

Letter No. 7.—Three Griffin Mills with 30-mesh screens representing about 84 HP., give us a cement 60% passing a 200-mesh sieve. The same three Griffins Mills, plus one small tube mill, representing in all about 116 HP., give us a cement, 74% of which passes the 200-mesh sieve. The cement in this case travels from the three Griffin Mills into the tube mill where it is reground. Summing it up, we have that an increase of fineness of 8% on 200-mesh sieve represents an increase of horse-power as well as increase of cost equal to 37%.

Letter No. 8.—We find upon inquiry at our works that it is possible to grind in one mill 7 barrels of cement per hour having a fineness of 70% on a 200 screen, while the same mill will grind only 4½ barrels per hour when the fineness is increased to 75% on a 200-mesh screen. In the first case, one barrel of cement is ground in about 8 4-7 minutes and in the latter case it takes 13⅓ minutes. You will notice that increasing the fineness of the cement decreases rapidly the output of the mill and consequently the cost of grinding proportionately. It is a mistake to grind cement too fine. The German manufacturers discovered this some years ago. They learned by experience that a cement ground too fine had less sand-carrying capacity than when ground to the fineness of about 75% on a 200-mesh screen. Engineers are constantly making requirements which greatly add to the cost of manufacture, but we do not find any of them willing to pay more for cement made to meet their requirements than they are required to pay for cements which do not.

Letter No. 9.—We recently made an experiment to find out how much decrease in capacity a tube mill would have by raising the fineness on a 200 sieve 10%. When we started the test the mill was grinding to a fineness of 78% on the 200 sieve, and we found that in order to increase the fineness to 88% on the 200 sieve it was necessary to reduce the capacity one-third; in other words, the mill would do one-third more grinding at 78% than at 88%.

Letter No. 10.—Upon receipt of your esteemed favor we started a series of tests with one of our tube mills. We adjusted the feed of the mill until the finished cement was of such fineness that 70% passed a 200-mesh screen, the output was then weighed and we found the mill was turning out 17½ barrels per hour. The feed was then cut down gradually until we secured a fineness of 75% passing the 200-mesh screen and we then had an output of 14¾ barrels per hour. From this test we find that increasing the fineness on a 200-mesh screen from 70% to 75% reduces the capacity of the mill 3¼ barrels per hour for each tube mill in operation.

A study of the foregoing letters makes it clear that the output of a cement plant is greatly decreased by adding 5% to the fineness of cement, above 70% through a 200-mesh sieve; and it should be evident to all that in the end the users of cement must pay for the additional cost of power, of labor, of superintendence, and of interest and depreciation of the plant. It is true enough that mills will work on occasional small orders for very fine cement, or even large orders in dull times, without adding materially to the selling price. But when the demand for cement is brisk a manufacturer would be foolish indeed to reduce his output 25 or 30% without adding correspondingly to his price. Then, again, the engineer should consider the cost arising from the delays that usually occur in securing materials that are "made to order"—for an unusually fine cement is as truly "made to order" as an unusual size of I-beam. Such indirect losses by delays often outweigh several times all direct gains.

It is argued that a finer cement has a greater sand carrying capacity, hence that the increased cost may be offset by the decreased quantity of cement required. But there seems to be an unwritten rule among American engineers not to burden cement with more than three parts of sand to one part of cement; and, in spite of the fact that fineness requirements have steadily become more rigorous, we note little tendency to increase the burden of sand. As a matter of fact if the mortar is made much leaner than 1 to 3, the voids in the sand will not be filled—which, for certain classes of work, is an objectionable feature.

For most uses to which cement is put it is as

yet impossible for us to estimate with any great degree of accuracy the stresses to which it will be subjected, and we shall long continue to use very large factors of safety in any case. The question then simmers down to this: Are not the present requirements for cement fineness rigorous enough for all practical purposes; and will it pay to specify cement of greater fineness than is now being made in the great majority of mills?

LETTERS TO THE EDITOR.

Longitudinal Shear in Beams.

Sir: On page 26 of Pencoyd Hand-Book, year 1900, is a rule for finding the longitudinal shear in a beam, as follows: "The intensity of the longitudinal shear at any section is the product of the vertical shear for that section and the statical moment of the section included between the plane of shear and the extreme fibers, divided by the product of the moment of inertia of the beam section and the thickness of the beam at the section where the shear is considered.

The rule is rather obscure in a good many points. Will you kindly solve the following problem in explanation? A Pencoyd 15-in. I-beam, at 42 lbs., 16-ft. long, is supported from the underside one foot from each end. It carries a concentrated load in center of 8 tons. What is the longitudinal shear on the center line of the web, 6 ins. from the end of the beam?

Yours very truly, M. J. W.

Chicago, Ill., July 19, 1904.

(Our correspondent's question is not fairly put. The beam he specifies overhangs its support 12 ins., and the section at which he wishes to find the shear is 6 ins. from the end, i. e., in the overhang. Since there is no vertical shear at this section (except that due to the weight of the overhang), there is no appreciable longitudinal shear; the rule cited does not apply to this case.

If we take the question to refer to a point 6 ins. inward from the support, the rule is simple to apply. The total vertical shear at that point equals the reaction, 8,000 lbs. The moment of inertia of the section is 440 in ⁴. The thickness of the beam at the point in question (middle of web) is 0.41 in. The statical moment of the upper half of the cross-section is not given in the tables, but must be computed. Remember that "statical moment" equals the summation of the products of areas multiplied by distance from moment-axis. For the half-section of 15 × 42 I-beam this is, neglecting fillets,

Web: 7.5 × 0.41 × 3.75 =	11.53
Flange: 5.09 × 0.41 × 7.30 =	15.23
+ 5.09 × ½ × 0.42 × 6.95 =	7.43
Total statical moment of half section around neutral axis =	34.19

Then the intensity of longitudinal shear is:

$$\frac{8{,}000 \times 34.2}{440 \times 0.41} = 1{,}520 \text{ lbs. per sq. in.}$$

It may be remarked, in connection with this question, that the analysis of distribution of shearing stress in beams as given in Burr's Elasticity and Resistance of Materials, p. 43, applies *only* to beams of rectangular cross-section. The formula quoted above from Pencoyd is of general applicability to all forms of cross-section.—Ed.)

Automatic Sprinkler Systems on Shipboard.

Sir: The letter signed by Mr. Everett U. Crosby in Engineering News of July 21, in which is advocated the installation of an automatic sprinkler system on board "our combustible passenger steamers," I have read with great interest, and while from an insurance agent's point of view the plan may appear feasible from the shipowner's it is quite impracticable, if not impossible. Mr. Crosby is apparently unmindful of the fact that what is perfectly adapted for duty ashore is seldom suitable for a similar service aboard steam vessels. The question of space on shipboard invariably determines the earning capacity of the vessel and to thrust additional burdens on owners is hardly justifiable in view of the very inadequate returns to those engaged in the operation of steamship lines.

To adopt Mr. Crosby's suggestion would require hundreds of feet of pipe lines, one or more large water tanks, an auxiliary pump, etc. To install water tanks on deck is a feature very undesirable and also dangerous, as it would seriously interfere with the stability of the vessel. The natural disposition to make of these encumbrances therefore would be in the engine room. Any one in the least familiar with the conditions prevailing in the engine rooms of modern steamships knows that the placing of additional and unnecessary machinery therein would tend to endanger the lives of passengers to a far greater extent than the total destruction of a vessel by fire occurring once in twenty years. Marine engines are extremely susceptible to break-downs, and with the engineer's attention required to other machinery in another part of the room it is not conducive to safety to obstruct his path to the throttle by cumbersome apparatus. Dangers constantly beset steamers while under way. A connecting rod given free rein by a broken crank-pin can perform amazing stunts with surprising celerity, and a liberated cylinder head knows no law but force.

The "General Slocum" was as safe a vessel as the average of those now in operation were she equipped with substantial fire apparatus and an intelligent crew educated to the duties required of them. But when owners despatch their vessels furnished with granulated cork life preservers, fire hose at 16 cts. per foot and place the deck force under the command of an ignorant and unlicensed mate—in direct violation of the United States laws—it is not strange that fire should overtake such a craft and consume her before her semi-intoxicated crew were aware of any unusual occurrence having taken place.

To obtain a greater degree of safety of passenger boats it is obviously unnecessary to discriminate against the owners by the enactment of laws making compulsory the carrying of weighty machinery of doubtful efficiency, but it can be fully realized by the rigid and impartial enforcement by inspectors who inspect the present laws relating to fire fighting apparatus on board steam vessels.

Very truly yours, Arthur R. Bush.

Boston, Mass., July 22, 1904.

The Present Condition of the Brooklyn Bridge Structure.

Sir: In your issue of July 21 were published three letters, addressed to the Municipal Art Commission, which criticized the latest design for the Manhattan bridge, as prepared by the present chief engineer of the bridge department.

In two of these letters reference is made to the Brooklyn bridge in a manner which is unjust to that structure and misleading to the public.

I beg to quote the respective paragraphs.

Professor Webb wrote:

> The Brooklyn bridge has shown that if such a structure be wanting in rigidity and strength, its life will be short, and it is commonly known among engineers that this bridge will need rebuilding within a few years. The principal weakness in the Brooklyn bridge is in the so-called stiffening trusses, whose office is to prevent a wave motion of the floor. To correct this fault, etc., etc.

Mr. Lindenthal wrote:

> The new design (of the Manhattan bridge) while in point of rigidity better than the worn-out Brooklyn bridge, etc., etc.

The references to the Brooklyn bridge in these two letters were probably hastily made, as they give a wrong impression of the condition of that structure. While I fully agree with Prof. Webb that the Brooklyn bridge needs rebuilding, it is not because the bridge is "wanting in rigidity and strength," nor because it is dilapidated or "worn out," nor because it will have a "short life;" but simply because the traffic has outgrown the capacity of the bridge. The travel will steadily increase, even if two other East River bridges will be in existence, and the bad accommodations, which already have reached the limit of endurance of the millions who depend on the bridge for going to their business or homes, will become unbearable. An enlargement of the bridge will, in a few years, be imperative, but the inconvenience connected with making the change will, then, be much greater than if it is done now or in the near future.

At several occasions, first in 1898 and again in 1901 and 1902, I have recommended such an improvement and have published illustrations and descriptions of how a double-deck bridge with twice its present capacity would be constructed at an expense of about four millions of dollars.

These publications are evidence of my conviction that the Brooklyn bridge is too small for the future traffic; but if the latter were to remain stationary and if the public were satisfied with the present accommodations, I would consider any reconstruction, outside of repairs and possibly some local improvements, unnecessary and wasteful. Contrary to that, it would appear from Prof. Webb's and Mr. Lindenthal's letters that the bridge is too weak for its present loads, and, altogether, in such bad condition that it ought to be rebuilt under any circumstances, even without enlarging its capacity. These imputations I take the liberty to contradict. The fact is that the Brooklyn bridge is to-day practically as good as when it was first finished. Well constructed bridges do not wear out. It is true, as may be expected, that the slip joints at the center of the bridge are considerably worn, but they can easily be repaired, and they are an immaterial part, which neither adds to nor detracts from the strength of the bridge.

During the 21 years since the bridge has been in service two accidents have happened to some parts of the structure; at one time a truss chord buckled and at another time 8 or 9 suspender rods broke. These incidents had special causes which were fully elucidated in Engineering News, and none of them was attributed to a general weakness or worn-out condition of the bridge. Moreover, with little expense and ordinary care the recurrence of such accidents can be avoided. In reality, these accidents were not more serious than the occasional breaking of rivet heads or bolts in girder and truss bridges.

That the bridge has ample strength, not only for the present but even for a heavier traffic, I have demonstrated by exact calculations in many discussions and published articles (see Engineering News of Jan. 16, 1902, and of Oct. 1, 1903). In point of rigidity, the Brooklyn bridge possesses all that a suspension bridge practically needs, and there is not a single case on record to show that "the want of rigidity" had caused any accident or inconvenience, or even that it had been noticed by any one. I have frequently explained that a stiffening construction adds nothing to the strength of a suspension bridge, and that it is more a luxury than a necessity. More rigidity than is needed for guarding the bridge against being a plaything of the wind and for preventing disagreeable or inconvenient undulations of the floor, is unnecessary and even undesirable. Eminent engineers agree that a reasonable degree of flexibility is a better quality of a suspension bridge than unlimited rigidity. The late Geo. S. Morison repeatedly expressed his opinion in that way and declared that a truss 10 ft. high would be ample for stiffening any highway bridge across the East River. The trusses of the Brooklyn bridge are 18 ft. high, and if they were too flexible and weak the effect would be visible in loose and broken rivets, rattling splices and worn-out pins. Nothing of that kind exists.

It will be remembered that three years ago the bridge was subjected to a critical examination by two engineers who had been engaged by District-Attorney Philbin. In the report of these engineers it was stated that the whole superstructure, in fact all essential parts of the bridge, were well preserved and in most excellent condition. That, nevertheless, the general tone of that report was adverse to the safety of the bridge, which at the time created considerable excitement, was not on account of the bad physical condition of the structure, but it was based on certain abstract theories which these engineers had derived and which they claimed had been neglected in the construction of the bridge.

The subject was thoroughly discussed in the Engineering News by many engineers, also by the writer in a full reply to that report, which was published Jan. 16, 1902, where the errors, committed by the two engineers in arriving at their conclusions, were clearly demonstrated. These demonstrations were never contradicted, the public confidence in the safety of the bridge seemed to be restored and the matter was laid at rest.

The importance of the Brooklyn bridge as a great thoroughfare is well understood. It has been said that no bridge in the world has a traffic of equal magnitude to that of the Brooklyn bridge which, during its time of existence, has safely carried upwards of 2,000 millions of people.

Therefore, in place of appointing a committee of engineers, as Professor Burr suggests in his letter to the Art Commission, for examining the new plans of the Manhattan bridge which are prepared by excellent and trustworthy engineers, I think that this community would be better served if such a committee would investigate all matters concerning the Brooklyn bridge. This committee would give to the public exact facts on which a judgment could be based, whether the bridge should be left as it is with all inconveniences of travel, or whether it should be at once sufficiently enlarged and strengthened for accommodating comfortably all traffic that in future may come upon it.

Wilhelm Hildenbrand, M. Am. Soc. C. E.

1 Broadway, New York, July 24, 1904.

The Water Supply Dilemma at Lawrence, Mass.

Sir: The City of Lawrence is still without its greatly needed additional filtering bed, and although plans for a sand filtration plant have been accepted, the appropriation of $70,000 asked of the city government to carry out the same is regarded as exorbitant, and is in consequence being withheld. As a result of this indecision, it now seems probable that no additional facilities for the purification of the water supply of the city will be provided this year. The officials of the water board have ascertained that the surrounding towns will allow connections with their mains as means of assistance in a water famine, which, it is claimed, cannot be averted under ordinary weather conditions during the coming winter.

The water supply of Lawrence is derived from the polluted Merrimack River. The present filter, the first of its sort to be built, was constructed in 1892, and for ten years it supplied the fast-growing city with pure water. In 1902, the need of additional facilities for filtration was realized, and in order to bridge over the coming winter $5,000 was spent in dividing the present uncovered bed into three sections. This plan was evolved by Mr. M. F. Collins, Superintendent of the Water-Works, and has proven successful, in that it saves much time in scraping, but one bed necessitating emptying at a time.

This tided the winter over satisfactorily, but during the following summer the pressing need was brought to the attention of the city government, and Messrs. Chapin & Knowles, of Pittsburg, were retained to draw plans for a new and covered bed, whose capacity should be 2,500,000 gallons per day. Such plans were drawn, providing for a filter similar to those at Albany, N. Y., and Philadelphia, Pa., to be located to the west of the present bed. The filter was to be 313 ft. long and 103 ft. wide inside, giving an affective area of about ¾ acre. The floor was to be in the form of inverted groined arches 6 ins. thick at the center and 15 ins. thick under the piers. The concrete piers to support the vaulting were to be 15 ft. c. to c., and 22 ins. square at the sand line, to batter out to 2½ ft. at the base. The vaulting was to be built of concrete in the form of semi-elliptical groined arches with a clear span of 13 ft. 2 ins., rise of 2 ft. 9 ins., and a thickness of 6 ins. at the crown, and 21 ins. over the piers.

In the operation of the filter it was intended that the river water should be carried from the present gate house, by gravity, to the inlet chamber in one corner of the filter, where the flow was to be regulated by a valve of special design. The water would then overflow the weirs in the walls of this chamber and be carried by open troughs, along the side walls of the filter. These troughs were to be provided with orifices of varying sizes, according to their position in the filter, so that the inflowing water would have been uniformly distributed over the whole area of the bed without disturbing the sand.

These plans were accepted, and it was fully expected that the required appropriation to allow work to be begun this spring would be forthcoming. City Engineer Marble made all surveys, and all was ready for immediate work. Haste was thought vitally necessary, as the winter just passed created the utmost apprehension in the minds of the water board officials. The severity of the past season made it practically impossible to keep the filter beds clear of ice and in working order, and as a result the reservoir had to furnish the deficiency. Never in the history of the city has the level of water in the reservoir fallen to a lower point, and had any serious conflagration broken out the filtered water supply would have been completely wiped out, necessitating recourse to the unpurified water of the Merrimack.

The city government was asked for an appropriation of $70,000 to do the work, the officials setting the figure high enough to cover all emergencies. At the same time the International Sewage Disposal Co., of Boston, offered to build a filter, acceptable to the state board of health, whose capacity should be 3,000,000 gallons per day, at a cost of but $30,000. The difference of $40,000 in the two estimates, especially as every means of retrenchment in the city's finances is being adopted, set the city fathers a-thinking. After much discussion it was voted to refer the project to the state board of health, and some weeks later it was rejected by that board. The rejection was not wholly unexpected, as the only plant of its sort, filtering water, is one at Brown University, which supplies the swimming tank. In its communication, by the hand of Secretary S. W. Abbott, the board said:

> The plans and the description of the proposed water purification plant provide for pumping the water from the Merrimack River into four sedimentation tanks having a capacity of 250,000 gallons, in which the water is to be allowed to settle for a period of two hours, and for filtering the water, after passing through the tanks, upon a filter composed of sand, gravel and broken stone, having an area of 22,200 sq. ft. and a depth of 5 ft. of filtering material, the whole to be enclosed in a building provided with skylights.
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At a later meeting of the committee in charge of this problem, this communication was received, as was one from B. F. Smith & Bros., of Boston, who desire to provide the city 2,000,000 gallons of pure water per day by means of their improved driven well system. They offer to sink wells in South Lawrence and provide a suitable water supply, at a cost of $48,000. This project is still in abeyance.

In comparing this filter with the sand system, Superintendent Collins has prepared the following figures, which indicate that the latter, while supplying a larger amount, is cheaper in maintenance. The slow sand filter, supplying 2,500,000 gallons, 365 days in a year, would furnish 912,500,000 gallons, at a cost of $12.51 per 1,000,000 gallons, including interest at 4% upon $70,000. The driven well system would supply 630,000,000 gallons in a like period at a cost of $13.39 per 1,000,000 gallons, including interest at 4% upon $48,000.

At this same meeting, President Chipman, of the Chipman Electric Purifying Co., of New York, appeared before the board and explained his system of water purification by electrolysis. This method consists of the running of the water through basins containing electrodes through which a current of electricity is continuously passing, thus separating all mineral and vegetable impurities from the fluid. The water then flows into clarifying tanks, where filter partitions remove all waste matter, leaving the water pure and clear. The proposition of the Chipman Company was to build an electrical filter plant, exclusive of the building, for approximately $20,000, to furnish 6,000,000 gallons of pure water per day. This water, he said, could be filtered at a cost of but $2.55 per 1,000,000 gallons.

As this plan was well thought of, it, too, was referred to the state board of health for its approval. Some weeks later the board declined to approve it. Since that time nothing has been done. Winter will soon be here, with no outlook for an adequate water supply for the city's inhabitants, unless it be by borrowing, which must be unsatisfactory.

J. Rodney Ball.

232 Bruce St., Lawrence, Mass., July 26, 1904.

(In a time of such emergency, and with a well-considered plan before it, it seems a pity that a city council should make a water board stand aside while the council turns itself into a body of experts to pass on all sorts of schemes, tried and untried, of increasing its water supply. Fortunately, however, nothing can be done without the approval of the State board of health. but, unfortunately, much can be left undone. If the council is not satisfied with the plans of the water board and the engineers employed by the board, why does it not refer the matter to some engineer of its own choosing?

Notes and Queries.

In the article on "Motor Cars on European Railways" in our issue of July 28, the saving of cost of the steam car service, as compared with train service on the London & Southwestern Ry., was given as 33%. This should be 66%, as is evident from the figures given in the table. In the description of the Turgan boiler (p. 30) the circulation was incorrectly given, the flow being down through the small tubes and returning through the larger tubes to the outer shell or drum.

The article on "Some Formulas and Tables for Bin Designing," by Mr. R. W. Dull, which was printed in our issue of July 21, 1904, pp. 62-66, contains several typographical errors requiring correction. Mr. Dull sends us the following corrections:

Page 62, col. 3, in Table of Constants for Steel-Plate Bins, Case 2, the weight of sand per cubic foot, given as 60, should be 90 lbs.

Page 63, col. 2, in Case 8, in the formula for E, the term printed

$$\frac{w}{z}\left(H^2 - h^2\right)$$

should read

$$\frac{w}{2}\left(H^2 - h^2\right)$$

i. e., the z should be changed to 2. In the line immediately following, the square-root sign before $\tan^2 a$ should extend over the whole of that line and the following line. The second term under this radical sign should have the last term of the numerator changed from

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Appointments have been offered to the three men who stood highest on this list, namely: Thomas F. Richardson, of Clinton, Mass.; Chas. E. Wells, Clinton, Mass. and Alexander E. Kastl, of Denver, Colo. This practically closes the matter, although the list of eligibles can under existing practice be utilized by various branches of the government service who may desire to select men from it for other positions.

THE GALVESTON SEA WALL, which is more than three miles long, has just been completed, and the filling in back of the wall has begun. It is estimated that the filling in will require two years and will cost $2,100,000, but when it is done the grade of streets in the lower part of the city will be 17 ft. above the present level.

A RAILWAY WATER TANK at Cumberland, W. Va. failed on July 22. The tank appears to have been of wood, and to have failed by bursting.

A PROPOSED "FIREPROOFED" WOOD ORDINANCE in New York City, designed to greatly extend the use of that material in tall buildings, was vetoed by Mayor McClellan last week, after its passage by the Board of Aldermen. (The ordinance was commented on, not favorably, in the editorial columns of our issue of July 21.) The reasons given by the Mayor for his veto are well grounded; two of them deserve special mention for the wisdom they display:

> I am of the opinion that in a technical matter of this character, I ought, as a matter of expediency, to be influenced largely by the opinion of the city department concerned, and the building departments of Manhattan and Brooklyn represent to me that this ordinance is inexpedient and unwise, and should not be approved.
>
> I am advised by the Board of Fire Underwriters that this ordinance does not, in their opinion, have the effect of increasing the safety from fire of buildings in this city, and also that, in their opinion, it should not be approved.

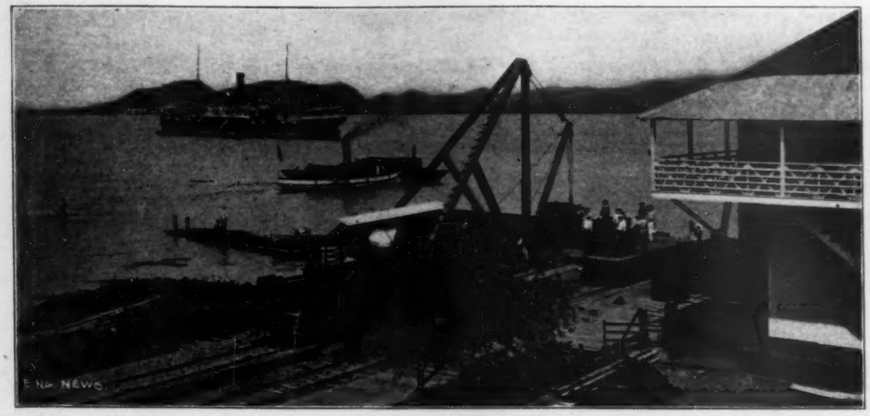
STRAY TROLLEY CURRENT is said to have killed two horses at Caldwell, N. J., on July 28. The driver of an ice wagon, according to a newspaper report was about to fill an order, and drew up in front of Rush's cigar store, when, without warning, one of the horses fell over dead in a pool of water in the roadway. Almost at the same moment the other horse fell as if it had received a shock. Carter (the driver.—Ed.) was badly frightened, and a man who was with him in the wagon was thrown out on the sidewalk. A number of men hurried to Carter's assistance, but no one ventured near the horses, as it was plain that they had been killed by electricity. It was noticed, too, that they had fallen toward a trolley pole in front of the store. No wires were down. The mystery was not explained until the trolley repair men arrived. Then it was shown that the insulation of the wires was defective, and that the pole became charged with the strong current, which in turn grounded and charged the pool of water into which the horses had stepped.

The question now is: What killed the horses?

SEWAGE POLLUTION AT NEW BEDFORD is endangering the little neck clam industry. The State Board of Health, it is reported, has requested the Fisheries and Game Commission to prevent the further taking of shellfish from the harbor and Clark's Cove at New Bedford.

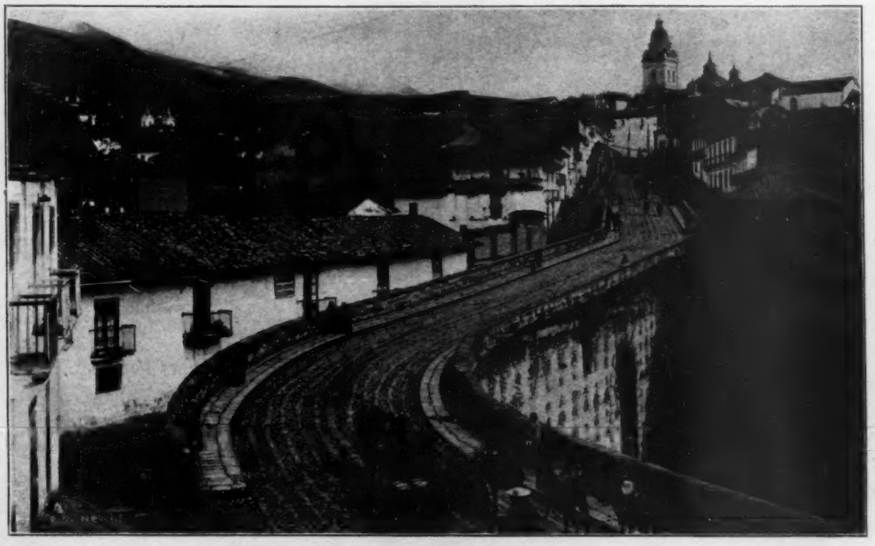
AN INSPECTION TRIP through the New York Rapid Transit underground railway was made on July 1 by a party composed of representatives of the technical papers in New York City. The start was made at the City Hall station and the inspection train, consisting of a flat car with seats, hauled by a small locomotive, proceeded to 116th St. on the West Side Line and then returned to the starting point. So far as the hasty inspection that was possible could determine, the remaining work on the portion of the subway that was visited appeared to consist only of painting and finishing the stations. Many of the stations were practically completed and only a few required much additional structural work to finish them. According to the latest statements, trains will not start running before Oct. 1, and it would seem from an examination of the work that this date is none too late for the completion of the main portion of the line. The trackwork is practically completed and the installation of the signal system appears to be completed also. The power plant is now ready to furnish power from three of its 7,500 HP. units.

WORKMEN'S TRAINS on the London, Brighton & South Coast Ry., in England, carry passengers at an average rate of about a farthing (½ ct.) per mile, according to the testimony of the company's General Manager before a Parliamentary Committee. The average receipts per passenger on these trains is only 1.69d. (3.4 cts.), indicating an average length of journey of less than seven miles. The company ran 35 workmen's trains in 1892, and now runs double the number.



TERMINUS OF GUAYAQUIL AND QUITO RY. AT DURAN, ACROSS THE BAY FROM GUAYAQUIL.

COCOANUT PALM.



CAUSEWAY AT ENTRANCE TO THE CITY OF QUITO.

MT. CHIMBORAZO, FROM A PHOTOGRAPH TAKEN AT 11,000

A BANANA GROVE.

A SUGAR CANE PLANTATION.

THE

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Appointments have been offered to the three men who stood highest on this list, namely: Thomas F. Richardson, of Clinton, Mass.; Chas. E. Wells, Clinton, Mass., and Alexander E. Kastl, of Denver, Colo. This practically closes the matter, although the list of eligibles remains under existing practice be utilized by various branches of the government service who may desire to select men from it for other positions.

THE GALVESTON SEA WALL, which is more than three miles long, has just been completed, and the filling in back of the wall has begun. It is estimated that the filling in will require two years and will cost $2,100,000, but when it is done the grade of streets in the lower part of the city will be 17 ft. above the present level.

A RAILWAY WATER TANK at Cumberland, W. Va., failed on July 22. The tank appears to have been

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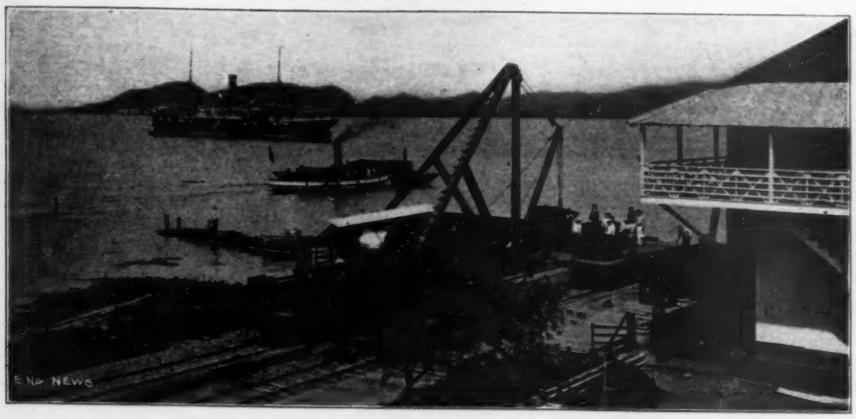
of Health, it is reported, has requested the Fisheries and Game Commission to prevent the further taking of shellfish from the harbor and Clark's Cove at New Bedford.

AN INSPECTION TRIP through the New York Rapid Transit underground railway was made on July 1 by a party composed of representatives of the technical papers in New York City. The start was made at the City Hall station and the inspection train, consisting of a flat car with seats, hauled by a small locomotive, proceeded to 116th St. on the West Side Line and then returned to the starting point. So far as the hasty inspection that was possible could determine, the remaining work on the portion of the subway that was visited appeared to consist only of painting and finishing the stations. Many of the stations were practically completed and only a few required much additional structural work to finish them. According to the latest statements, trains will not start running before Oct. 1, and it would seem from an examination of the work that this date is none too late for the completion of the main portion of the line. The trackwork is practically completed and the installation of the signal system appears to be completed also. The power plant is now ready to furnish power from three of its 7,500 HP. units.

WORKMEN'S TRAINS on the London, Brighton & South Coast Ry., in England, carry passengers at an average rate of about a farthing (½ ct.) per mile, according to the testimony of the company's General Manager before a Parliamentary Committee. The average receipts per passenger on those trains is only 1.69d. (3.4 cts.), indicating an average length of journey of less than seven miles. The company ran 35 workmen's trains in 1892, and now runs double the number.



TERMINUS OF GUAYAQUIL AND QUITO RY. AT DURAN, ACROSS THE BAY FROM GUAYAQUIL.

COCOANUT PALM.

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CITY OF QUITO.

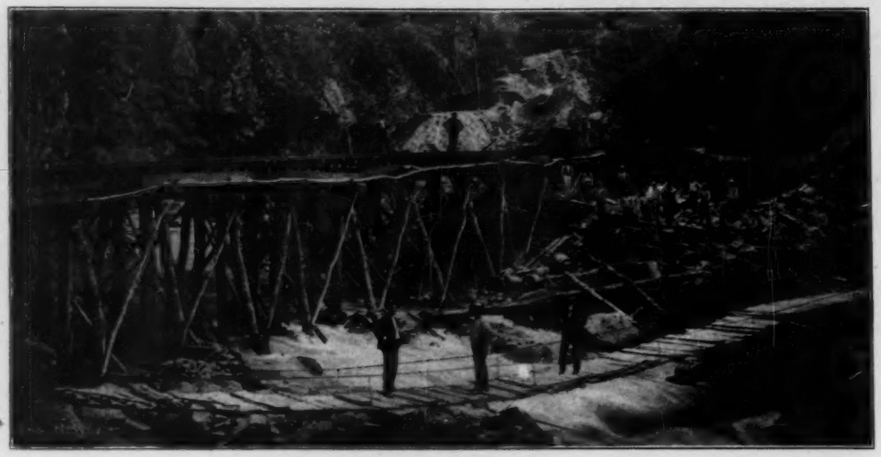
MT. CHIMBORAZO, FROM A PHOTOGRAPH TAKEN AT 11,000

A BANANA GROVE.

A SUGAR CANE PLANTATION.

THE
GUAYAQUIL & QUITO RY.
OF ECUADOR.

PALM.



FALSEWORK FOR BRIDGE 23, OCT. 18, 1901.

AKEN AT 11,000 FT. ELEVATION.

TUNNEL NO. 3 (69 FT. LONG).

NTATION.

JITO RY.

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THE CITY OF AMBATO.